

**2001 California Energy Code  
California Code of Regulations, Title 24, Part 6**

PUBLISHED

by

**International Conference of Building Officials**

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# *Preface*

This document is Part 6 of the official 2001 triennial compilation and publication of the adoptions, amendments, and repeal of building regulations to the California Code of Regulations, Title 24, also referred to as the *California Building Standards Code*. This part is known as the *California Energy Code*.

The *California Building Standards Code* is published in its entirety every three years by order of the California legislature, with supplements published in intervening years. The California legislature delegated authority to various state agencies, boards, commissions, and departments to create building regulations to implement the state's statutes. These building standards have the same force of law, and take effect 180 days after publication, unless otherwise stipulated. The *California Building Standards Code* applies to all occupancies throughout the State of California as annotated.

A city, county, or city and county may establish more restrictive building standards reasonably necessary because of local climatic, geological, or topographical conditions. Findings of the local condition(s) and the adopted local building standard(s) must be filed with the California Building Standards Commission to become effective and may not be effective sooner than the effective date of this edition of the *California Building Standards Code*. Local building standard(s) adopted to be applicable to previous editions of the *California Building Standards Code* do not apply to this edition without appropriate adoption and the required filing.

Should you have any questions regarding this code or wish to offer comments toward improving the format, please address your questions and comments to:

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## ***How to Determine Where Changes Have Been Made***

Symbols in the margins indicate where changes have been made or language has been deleted.

|| This symbol indicates that a change has been made.

> This symbol indicates deletion of language.



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## SUBCHAPTER 1

### ALL OCCUPANCIES—GENERAL PROVISIONS

#### SECTION 100 — SCOPE

(a) **Buildings Covered.** The provisions of Title 24, Part 6, apply to all buildings:

1. That are of Occupancy Group A, B, E, F, H, M, R or S; and
2. For which an application for a building permit or renewal of an existing permit is filed (or is required by law to be filed) on or after the effective date of the provisions, or which are constructed by a governmental agency; and
3. That are:
  - A. Directly or indirectly conditioned by mechanical heating or mechanical cooling; or
  - B. Low-rise residential buildings that are heated with a wood heater or another nonmechanical heating system; or
  - C. Semiconditioned nonresidential occupancies.

**EXCEPTION 1 to Section 100 (a):** Qualified historic buildings as defined in the State Historic Building Code (Title 24, Part 8).

**EXCEPTION 2 to Section 100 (a):** Building departments, at their discretion, may exempt temporary buildings or structures erected in response to a natural disaster. Temporary buildings or structures shall be completely removed upon the expiration of the time limit stated in the permit.

(b) **Parts of Buildings Regulated.** The provisions of Title 24, Part 6, apply to the building envelope, space-conditioning systems, water-heating systems and lighting systems of buildings covered by Section 100 (a) as set forth in Table 1-A.

(c) **Floors and Habitable Stories.**

1. Only habitable floors that have at least 50 percent of their volume above grade as defined in the UBC shall be counted in determining how many habitable stories a building has.
2. All conditioned space in a floor shall comply with Title 24, Part 6, whether or not the floor is above grade and whether or not it is habitable.

(d) **Sections Applicable to Particular Buildings.** Table 1-A and this subsection list the provisions of Title 24, Part 6, that are applicable to different types of buildings covered by Section 100 (a).

1. **All buildings.** Sections 100 through 109 and 118 apply to all buildings.

2. **New buildings.**

- A. **All new buildings.** Sections 110 through 119 apply to all new buildings within the scope of Section 100 (a). In addition, new buildings shall meet the requirements of B or C, as applicable.
- B. **Nonresidential, high-rise residential, and hotel/motel buildings that are mechanically heated or mechanically cooled.**
  - i. **Sections applicable.** Sections 120 through 146 apply to new nonresidential buildings, high-rise residential buildings, and hotels/motels that are mechanically heated or mechanically cooled.
  - ii. **Compliance approaches.** In order to comply with Title 24, Part 6, new nonresidential buildings, high-rise residential buildings, and hotels/motels that

are mechanically heated or mechanically cooled must meet the requirements of:

- a. **Mandatory measures:** The applicable provisions of Sections 120 through 139; and
- b. **Either:**
  - Performance approach: Section 141; or
  - Prescriptive approach: Sections 142 through 146.

C. **Semiconditioned nonresidential buildings.** Sections 119, 130 through 132, and 146 apply to all new unconditioned buildings within the scope of Section 100 (a).

D. **Low-rise residential buildings that are heated or mechanically cooled.**

- i. **Sections applicable.** Sections 150 through 151 apply to new low-rise residential buildings that are heated or mechanically cooled.
- ii. **Compliance approaches.** To comply with Title 24, Part 6, new low-rise residential buildings that are heated or mechanically cooled must meet the requirements of:
  - a. **Mandatory measures:** The applicable provisions of Sections 110 through 119, and 150; and
  - b. **Either:**
    - Performance approach: Section 151 (a) through (e); or
    - Prescriptive approach: Sections 151 (a) and (f).

**EXCEPTION 1 to Section 100 (d) 2 D (ii) (b):** Seasonally occupied agricultural housing limited by state or federal agency contract to occupancy not more than 180 days in any calendar year.

**EXCEPTION 2 to Section 100 (d) 2 D (ii) (b):** Low-rise residential buildings that are heated with a wood heater or another nonmechanical heating system and that use no energy obtained from depletable sources for lighting or water heating.

3. **New construction in existing buildings.**

- A. **Nonresidential, high-rise residential, and hotel/motel buildings.** Section 149 applies to new construction in existing buildings that will be nonresidential, high-rise residential, and hotel/motel occupancies.
- B. **Semiconditioned nonresidential buildings.** Section 149 (b) 3 applies to new construction in an existing semi-conditioned building. If new construction results in newly conditioned space, Section 149 (a) shall apply.
- C. **Low-rise residential buildings.** Section 152 applies to new construction in existing buildings that will be low-rise residential occupancies.

4. **Installation of insulation in existing buildings.** Section 118 applies to buildings in which insulation is being installed in existing attics, or on existing water heaters or existing space conditioning ducts.

(e) **Mixed Occupancy.** When a building is designed and constructed for more than one type of occupancy, the space for each occupancy shall meet the provisions of Title 24, Part 6, applicable to that occupancy.

**EXCEPTION to Section 100 (e):** If one occupancy constitutes at least 90 percent of the conditioned floor area of the building, the entire

building may comply with the provisions of Title 24, Part 6 applicable to that occupancy, provided that the applicable mandatory measures in Sections 110 through 139, and 150, are met for each occupancy.

(f) **Administrative Requirements.** Administrative requirements relating to permit requirements, enforcement by the Commission, locally adopted energy standards, interpretations, claims of exemption, approved calculation methods, and rights of appeal are specified in California Code of Regulations, Title 24, Part 1, Sections 10-101 to 10-112.

(g) **Certification Requirements for Manufactured Devices.** Title 24, Part 6, limits the installation of the following manufactured devices to those that have been certified by their manufacturer to meet or exceed minimum specifications or efficiencies by the Commission.

1. Central air-conditioning heat pumps and other central air conditioners (Sections 111 and 112).
2. Combination equipment: space heating and cooling, or space heating and water heating [Section 112 (a) 3].
3. Fenestration products (Section 116).
4. Fluorescent lamp ballasts (Section 111).
5. Gas space heaters (Sections 111 and 112).
6. Insulating materials (Section 118).
7. Lighting control devices (Section 119).
8. Oil fired storage water heaters (Section 113).
9. Other heating and cooling equipment (Sections 111 and 112).
10. Plumbing fittings (Section 111).
11. Pool heaters (Section 114).
12. Refrigerators, refrigerator-freezers and freezers (Section 111).
13. Room air conditioners (Section 111).
14. Slab floor perimeter insulation [Section 150 (l)].
15. Water heaters (Section 113).

The certification status of any such manufactured device may be confirmed only by reference to:

1. A directory published or approved by the Commission; or
2. A copy of the application for certification from the manufacturer and the letter of acceptance from the Commission staff; or
3. Written confirmation from the publisher of a Commission-approved directory that a device has been certified; or
4. A Commission-approved label on the device.

**NOTE to Section 100 (g):** Title 24, Part 6, does not require a builder, designer, owner, operator or enforcing agency to test any certified device to determine its compliance with minimum specifications or efficiencies adopted by the Commission.

## SECTION 101 — DEFINITIONS AND RULES OF CONSTRUCTION

### (a) Rules of Construction.

1. Where the context requires, the singular includes the plural and the plural includes the singular.
2. The use of “and” in a conjunctive provision means that all elements in the provision must be complied with, or must exist to make the provision applicable. Where compliance with one or more elements suffices, or where existence of one or more elements makes the provision applicable, “or” (rather than “and/or”) is used.

3. “Shall” is mandatory and “may” is permissive.

(b) **Definitions.** Terms, phrases, words and their derivatives in Title 24, Part 6, shall be defined as specified in Section 101. Terms, phrases, words and their derivatives not found in Section 101 shall be defined as specified in Title 24, Part 2, Chapter 2 of the California Code of Regulations. Terms, phrases, words and their derivatives not found in either Title 24, Part 6, or Chapter 2 shall be defined as specified in Title 24, Part 2, Chapter 2 of the *Uniform Building Code*. Where terms, phrases, words and their derivatives are not defined in any of the references above, they shall be defined as specified in *Webster’s Third New International Dictionary of the English Language, Unabridged* (1987 edition), unless the context requires otherwise.

**ACCA** is the Air-conditioning Contractors of America.

**ACCESSIBLE** is having access thereto, but which first may require removal or opening of access panels, doors, or similar obstructions.

**ADDITION** is any change to a building that increases conditioned floor area and conditioned volume. See also, “newly conditioned space.”

**AIR-TO-AIR HEAT EXCHANGER** is a device which will reduce the heat losses or gains which occur when a building is mechanically ventilated, by transferring heat between the conditioned air being exhausted and the unconditioned air being supplied.

**ALTERATION** is any change to a building’s water-heating system, space-conditioning system, lighting system or envelope that is not an addition.

**ALTERNATIVE CALCULATION METHODS (ACMs)** are the commission’s Public Domain Computer Programs, one of the commission’s Simplified Calculation Methods, or any other calculation method approved by the commission.

**ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE)** is a measure of the percentage of heat from the combustion of gas or oil which is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

**ANNUNCIATED** is a visual signaling device that indicates the on, off, or other status of a load.

**ANSI** is the American National Standards Institute.

**APPLIANCE EFFICIENCY REGULATIONS** are the regulations in Title 20, Sections 1601 et seq. of the California Code of Regulations.

**APPROVED BY THE COMMISSION** means approval under Section 25402.1 of the Public Resources Code.

**APPROVED CALCULATION METHOD** (See “alternative calculation methods.”)

**ARI** is the Air-conditioning and Refrigeration Institute.

**ASHRAE** is the American Society of Heating, Refrigerating and Air-conditioning Engineers.

**ASME** is the American Society of Mechanical Engineers.

**ASTM** is the American Society for Testing and Materials.

**ATRIUM** is an opening through two or more floor levels other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning or other equipment, which is enclosed space and not defined as a mall.

**AUTOMATIC** is capable of operating without human intervention.

**AUTOMATIC TIME SWITCH CONTROL DEVICES** are devices capable of automatically turning loads off and on based on time schedules.

**BELOW-GRADE WALL** is the portion of a wall, enclosing conditioned space, that is below the grade line.

**BUILDING** is any structure or space for which a permit is sought.

**BUILDING ENVELOPE** is the ensemble of exterior and demising partitions of a building that enclose conditioned space.

**CAPTIVE-KEY OVERRIDE** is a type of lighting control in which the key that activates the override cannot be released when the lights are in the on position.

**CERTIFYING ORGANIZATION** is an independent organization recognized by the commission to certify manufactured devices for performance values in accordance with procedures adopted by the commission.

**CHANDELIERS** (See “ornamental chandeliers.”)

**CLIMATE CONTROL SYSTEM** (See “space-conditioning system.”)

**CLIMATE ZONES** are the 16 geographic areas of California for which the commission has established typical weather data, prescriptive packages and energy budgets. Climate zone boundary descriptions are in the document “California Climate Zone Descriptions” (July 1995), incorporated herein by reference. Figure 1-A is an approximate map of the 16 climate zones.

**CMC** is the 1998 *California Mechanical Code* prior to the effective date designated by the California Building Standards Commission for the 2000 *California Mechanical Code*. On and after the effective date designated by the California Building Standards Commission for the 2000 *California Mechanical Code*, CMC is the 2000 *California Mechanical Code*.

**COEFFICIENT OF PERFORMANCE (COP), COOLING**, is the ratio of the rate of net heat removal to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

**COEFFICIENT OF PERFORMANCE (COP), HEATING**, is the ratio of the rate of net heat output to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

**COMMISSION** is the California State Energy Resources Conservation and Development Commission.

**COMPLETE BUILDING** is an entire building with one occupancy making up 90 percent of the conditioned floor area (see also “entire building”).

**CONDITIONED FLOOR AREA (CFA)** is the floor area (in square feet) of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing the conditioned space.

**CONDITIONED SPACE** is space in a building that is either directly conditioned, indirectly conditioned or semiconditioned.

**CONDITIONED VOLUME** is the total volume (in cubic feet) of the conditioned space within a building.

**COOL ROOF** is a roofing material with high solar reflectance and high emittance that reduces heat gain through the roof.

**COOLING EQUIPMENT** is equipment used to provide mechanical cooling for a room or rooms in a building.

**COVERED PRODUCT** is an appliance regulated by the efficiency standards established under the National Appliance Energy Conservation Act, 42 U.S.C., Section 6291 et seq.

**CRAWL SPACE** is a space immediately under the first floor of a building adjacent to grade.

**CTI** is the Cooling Tower Institute.

**C-VALUE** (also known as C-factor) is the time rate of heat flow through unit area of a body induced by a unit temperature difference between the body surfaces, in Btu (hr. x ft.<sup>2</sup> x °F). It is not the same as K-value or K-factor.

**DAYLIT AREA** is the space on the floor that is the larger of 1 plus 2, or 3;

1. For areas daylit by vertical glazing, the daylit area has a length of 15 feet, or the distance on the floor, perpendicular to the glazing, to the nearest 60-inch or higher opaque partition, whichever is less; and a width of the window plus either 2 feet on each side, the distance to an opaque partition, or one half the distance to the closest skylight or vertical glazing, whichever is least.

2. For areas daylit by horizontal glazing, the daylit area is the footprint of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of the floor-to-ceiling height, the distance to the nearest 60-inch or higher opaque partition, or one half the horizontal distance to the edge of the closest skylight or vertical glazing.

3. The daylit area calculated using a method approved by the commission.

**DECORATIVE GAS APPLIANCE** is a gas appliance that is designed or installed for visual effect only, cannot burn solid wood, and simulates a fire in a fireplace.

**DEGREE DAY, HEATING**, is a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65°F, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F. The number of degree days for specific geographical locations are those listed in the Residential Manual. For those localities not listed in the Residential Manual, the number of degree days is as determined by the applicable enforcing agency.

**DEMISING PARTITIONS** are barriers that separate conditioned space from enclosed unconditioned space.

**DEMISING WALL** is a wall that is a demising partition.

**DESIGN CONDITIONS** are the parameters and conditions used to determine the performance requirements of space-conditioning systems. Design conditions for determining design heating and cooling loads are specified in Section 144 (b) for nonresidential, high-rise residential, and hotel/motel buildings and in Section 150 (h) for low-rise residential buildings.

**DESIGN HEAT GAIN RATE** is the total calculated heat gain through the building envelope under design conditions.

**DESIGN HEAT LOSS RATE** is the total calculated heat loss through the building envelope under design conditions.

**DIRECTLY CONDITIONED SPACE** is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/(hr. • ft.<sup>2</sup>), or is provided with mechanical cooling that has a capacity exceeding 5 Btu/(hr. • ft.<sup>2</sup>), unless the space-conditioning system is designed and thermostatically controlled to maintain a process environment temperature less than 55°F or to maintain a process environment temperature greater than 90°F for the whole space that the system serves, or unless the space-conditioning system is designed and controlled to be incapable of operating at temperatures above 55°F or incapable of operating at temperatures below 90°F at design conditions.

**DISPLAY LIGHTING** is lighting confined to the area of a display that provides a higher level of illuminance than the level of surrounding ambient illuminance.

**DISPLAY PERIMETER** is the length of an exterior wall in a Group B; Group F, Division 1; or Group M Occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.

**DISPLAY, PUBLIC AREA**, is an area for the display of art-work, theme displays and architectural surfaces in dining and other areas of public access, excluding restrooms and separate banquet rooms.

**DISPLAY, SALES FEATURE**, is an item or items that requires special highlighting to visually attract attention and that is visually set apart from the surrounding area.

**DISPLAY, SALES FEATURE FLOOR**, is a feature display in a retail store, wholesale store or showroom that requires display lighting.

**DISPLAY, SALES FEATURE WALL**, is the wall display area, in a retail or wholesale space, that is in the vertical plane of permanent walls or partitions, and that is open shelving feature display or face of internally illuminated transparent feature display case within the gross sales wall area.

**DUAL-GLAZED GREENHOUSE WINDOWS** are a type of dual-glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

**DUCT SEALING** is a procedure for installing a space-conditioning distribution system that minimizes leakage of conditioned air. Minimum specifications for installation procedures, materials, diagnostic testing and field verification are contained in the Residential and Nonresidential ACM Approval Manuals.

**EAST-FACING** is oriented to within 45 degrees of true east, including 45°00'00" south of east (SE), but excluding 45°00'00" north of east (NE).

**ECONOMIZER, AIR**, is a ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical cooling.

**ECONOMIZER, WATER**, is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water, or other appropriate fluid, in order to reduce or eliminate the need for mechanical cooling.

**EFFECTIVE APERTURE (EA)** is (1) for windows, the visible light transmittance (VLT) times the window wall ratio; and (2) for skylights, the well index times the VLT times the skylight area times 0.85 divided by the gross exterior roof area.

**EFFICACY** is the ratio of light from a lamp to the electrical power consumed (including ballast losses), expressed in lumens per watt.

**ENCLOSED SPACE** is space that is substantially surrounded by solid surfaces.

**ENERGY BUDGET** is the maximum amount of source energy that a proposed building, or portion of a building, can be designed to consume, calculated with the approved procedures specified in Title 24, Part 6.

**ENERGY EFFICIENCY RATIO (EER)** is the ratio of net cooling capacity (in Btu/hr.) to total rate of electrical energy (in watts), of a cooling system under designated operating conditions, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

**ENERGY FACTOR (EF)** is the ratio of energy output to energy consumption of a water heater, expressed in equivalent units,

under designated operating conditions over a 24-hour use cycle, as determined using the applicable test method in the Appliance Efficiency Regulations.

**ENERGY OBTAINED FROM DEPLETABLE SOURCES** is electricity purchased from a public utility, or any energy obtained from coal, oil, natural gas, or liquefied petroleum gases.

**ENERGY OBTAINED FROM NONDEPLETABLE SOURCES** is energy that is not energy obtained from depletable sources.

**ENFORCING AGENCY** is the city, county, or state agency responsible for issuing a building permit.

**ENTIRE BUILDING** is the ensemble of all enclosed space in a building, including the space for which a permit is sought, plus all existing conditioned and unconditioned space within the structure.

**ENVELOPE** means "building envelope."

**EXFILTRATION** is uncontrolled outward air leakage from inside a building, including leakage through cracks and interstices, around windows and doors, and through any other exterior partition or duct penetration.

**EXTERIOR DOOR** is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one half of the door area. Doors with a glazed area of more than one half of the door area are treated as a fenestration product.

**EXTERIOR FLOOR/SOFFIT** is a horizontal exterior partition, or a horizontal demising partition, under conditioned space. For low-rise residential occupancies, exterior floors also include those on grade.

**EXTERIOR PARTITION** is an opaque, translucent or transparent solid barrier that separates conditioned space from ambient air or space that is not enclosed. For low-rise residential occupancies, exterior partitions also include barriers that separate conditioned space from unconditioned space, or the ground.

**EXTERIOR ROOF/CEILING** is an exterior partition, or a demising partition, that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.

**EXTERIOR ROOF/CEILING AREA** is the area of the exterior surface of exterior roof/ceilings.

**EXTERIOR WALL** is any wall or element of a wall, or any member or group of members, which defines the exterior boundaries or courts of a building and which has a slope of 60 degrees or greater with the horizontal plane. An exterior wall or partition is not an exterior floor/soffit, exterior door, exterior roof/ceiling, window, skylight or demising wall.

**EXTERIOR WALL AREA** is the area of the opaque exterior surface of exterior walls.

**FENESTRATION PRODUCT** is any transparent or translucent material plus any sash, frame, mullions and dividers, in the envelope of a building, including, but not limited to, windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one half of the door area.

**FENESTRATION SYSTEM** means a collection of fenestration products included in the design of a building. (See "fenestration product.")

**FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR** is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fab-

ricate a fenestration product or exterior door. Field fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits and curtain walls).

**FIREPLACE** is a hearth and firechamber or similar prepared place in which a solid-fuel fire may be burned, as defined in UBC Section 3102.2 and as further clarified in UBC Section 3102.7; these include, but are not limited to, factory-built fireplaces, masonry fireplaces, and masonry heaters.

**FLOOR/SOFFIT TYPE** is a floor/soffit assembly having a specific heat capacity, framing type, and U-factor.

**FRAMED PARTITION** or **ASSEMBLY** is a partition or assembly constructed using separate structural members spaced not more than 32 inches on center.

**GAS HEATING SYSTEM** is a natural gas or liquefied petroleum gas heating system.

**GAS LOG** is a self-contained, free-standing, open-flame, gas-burning appliance consisting of a metal frame or base supporting simulated logs, and designed for installation only in a vented fireplace.

**GENERAL LIGHTING** is lighting designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect. When designed for lower-than-task illuminance used in conjunction with other specific task lighting systems, it is also called "ambient" lighting.

**GLAZING** (See "fenestration product.")

**GOVERNMENTAL AGENCY** is any public agency or subdivision thereof, including, but not limited to, any agency of the state, a county, a city, a district, an association of governments, or a joint power agency.

**GROSS EXTERIOR ROOF AREA** is the sum of the skylight area and the exterior roof/ceiling area.

**GROSS EXTERIOR WALL AREA** is the sum of the window area, door area and exterior wall area.

**GROSS SALES FLOOR AREA** is the total area (in square feet) of retail store floor space that is (1) used for the display and sale of merchandise; or (2) associated with that function, including, but not limited to, sales transactions areas, fitting rooms, and circulation areas and entry areas within the space used for display and sale.

**GROSS SALES WALL AREA** is the area (in square feet) of the inside of exterior walls and permanent full-height interior partitions within the gross sales floor area of a retail store that is used for the presentation of merchandise for sale, less the area of openings, doors, windows, baseboards, wainscots, mechanical or structural elements, and other obstructions preventing the use of the area for the presentation of merchandise.

**HABITABLE STORY** is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

**HEAT CAPACITY (HC)** of an assembly is the amount of heat necessary to raise the temperature of all the components of a unit area in the assembly 1 °F. It is calculated as the sum of the average thickness times the density times the specific heat for each component, and is expressed in Btu per square foot per °F.

**HEAT PUMP** is a device that is capable of heating by refrigeration, and that may include a capability for cooling.

**HEATING EQUIPMENT** is equipment used to provide mechanical heating for a room or rooms in a building.

**HEATING SEASONAL PERFORMANCE FACTOR (HSPF)** is the total heating output of a heat pump (in Btu) during its normal use period for heating divided by the total electrical energy input (in watt-hours) during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

**HI** is the Hydronics Institute.

**HIGH BAY** is a space with luminaires 25 feet or more above the floor.

**HIGH-RISE RESIDENTIAL BUILDING** is a building, other than a hotel/motel, of occupancy Group R, Division 1 with four or more habitable stories.

**HORIZONTAL GLAZING** (See "skylight.")

**HOTEL/MOTEL** is a building or buildings incorporating six or more guest rooms or a lobby serving six or more guest rooms, where the guest rooms are intended or designed to be used, or which are used, rented, or hired out to be occupied, or which are occupied for sleeping purposes by guests, and all conditioned spaces within the same building envelope. Hotel/motel also includes all conditioned spaces which are (1) on the same property as the hotel/motel, (2) served by the same central heating, ventilating, and air-conditioning system as the hotel/motel, and (3) integrally related to the functioning of the hotel/motel as such, including, but not limited to, exhibition facilities, meeting and conference facilities, food service facilities, lobbies and laundries.

**HVAC SYSTEM** (See "space-conditioning system.")

**ICBO** is the International Conference of Building Officials.

**ILLUMINATED FACE** is a side of an exit sign that has the word "EXIT" on it.

**INDIRECTLY CONDITIONED SPACE** is enclosed space, including, but not limited to, unconditioned volume in atria, that (1) is not directly conditioned space; and (2) either (a) has an area-weighted heat transfer coefficient to directly conditioned space exceeding that to the outdoors or to unconditioned space, or (b) is a space through which air from directly conditioned spaces is transferred at a rate exceeding three air changes per hour.

**INFILTRATION** is uncontrolled inward air leakage from outside a building or unconditioned space, including leakage through cracks and interstices, around windows and doors, and through any other exterior or demising partition or pipe or duct penetration.

**INTEGRATED PART LOAD VALUE (IPLV)** is a single-number figure of merit based on part load EER or COP expressing part load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

**ISOLATION DEVICE** is a device that prevents the conditioning of a zone or group of zones in a building while other zones of the building are being conditioned.

**LOW BAY** is a space with luminaires less than 25 feet above the floor.

**LOW-RISE RESIDENTIAL BUILDING** is a building, other than a hotel/motel that is of Occupancy Group R, Division 1, and is three stories or less, or that is of Occupancy R, Division 3.

**LPG** is liquefied petroleum gas.

**LUMINAIRE** is a complete lighting unit consisting of a lamp and the parts designed to distribute the light, to position and pro-

tect the lamp, and to connect the lamp to the power supply; commonly referred to as “lighting fixtures” or “instruments.”

**MANUAL** is capable of being operated by personal intervention.

**MANUFACTURED DEVICE** is any heating, cooling, ventilation, lighting, water heating, refrigeration, cooking, plumbing fitting, insulation, door, fenestration product, or any other appliance, device, equipment, or system subject to Sections 110 through 119 of Title 24, Part 6.

**MANUFACTURED FENESTRATION PRODUCT** is a fenestration product typically assembled before delivery to a job site. A “knocked-down” or partially assembled product sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

**MECHANICAL COOLING** is lowering the temperature within a space using refrigerant compressors or absorbers, desiccant dehumidifiers, or other systems that require energy from depletable sources to directly condition the space. In nonresidential, high-rise residential, and hotel/motel buildings, cooling of a space by direct or indirect evaporation of water alone is not considered mechanical cooling.

**MECHANICAL HEATING** is raising the temperature within a space using electric resistance heaters, fossil fuel burners, heat pumps, or other systems that require energy from depletable sources to directly condition the space.

**MODELING ASSUMPTIONS** are the conditions (such as weather conditions, thermostat settings and schedules, internal gain schedules, etc.) that are used for calculating a building’s annual energy consumption and that are in the Alternative Calculation Methods Manuals.

**MOVABLE SHADING DEVICE** (See “operable shading device.”)

**MULTISCENE DIMMING SYSTEM** is a lighting control device that has the capability of setting light levels throughout a continuous range, and that has pre-established settings within the range.

**NEWLY CONDITIONED SPACE** is any space being converted from unconditioned to directly conditioned or indirectly conditioned space, or any space being converted from semiconditioned to directly conditioned or indirectly conditioned space. Newly conditioned space must comply with the requirements for an addition. See Section 149 for nonresidential occupancies and Section 152 for residential occupancies.

**NONRESIDENTIAL BUILDING** is any building which is a Group A, B, E, F, H, M or S Occupancy.

**NOTE:** Requirements for high-rise residential buildings and hotels/motels are included in the nonresidential sections of Title 24, Part 6.

**NONRESIDENTIAL MANUAL** is the manual developed by the commission, under Section 25402.1 (e) of the Public Resources Code, to aid designers, builders and contractors in meeting the energy efficiency requirements for nonresidential, high-rise residential, and hotel/motel buildings.

**NORTH-FACING** is oriented to within 45 degrees of true north, including 45°00’00” east of north (NE), but excluding 45°00’00” west of north (NW).

**OCCUPANCY SENSOR, LIGHTING**, is a device that automatically turns lights off soon after an area is vacated.

**OCCUPANCY TYPE** is one of the following:

**Auditorium** is the part of a public building where an audience sits in fixed seating, or a room, area, or building with fixed seats

used for public meetings or gatherings not specifically for the viewing of dramatic performances.

**Auto repair** is the portion of a building used to repair automotive equipment and/or vehicles, exchange parts, and may include work using an open flame or welding equipment.

**Bank/financial institution** is an area in a public establishment used for conducting financial transactions including the custody, loan, exchange, or issue of money, for the extension of credit, and for facilitating the transmission of funds.

**Classroom, lecture, or training** is a room or area where an audience or class receives instruction.

**Commercial and industrial storage** is a room, area, or building used for storing items.

**Convention, conference, multipurpose and meeting centers** is an assembly room, area, or building that is used for meetings, conventions and multiple purposes, including, but not limited to, dramatic performances, and that has neither fixed seating nor fixed staging.

**Corridor** is a passageway or route into which compartments or rooms open.

**Dining** is a room or rooms in a restaurant or hotel/motel (other than guest rooms) where meals that are served to the customers will be consumed.

**Electrical/mechanical room** is a room in which the building’s electrical switchbox or control panels, and/or HVAC controls or equipment is located.

**Exercise center/gymnasium** is a room or building equipped for gymnastics, exercise equipment, or indoor athletic activities.

**Exhibit** is a room or area that is used for exhibitions that has neither fixed seating nor fixed staging.

**General commercial and industrial work** is a room, area, or building in which an art, craft, assembly or manufacturing operation is performed.

**High bay:** Luminaires 25 feet or more above the floor.

**Low bay:** Luminaires less than 25 feet above the floor.

**Grocery store** is a room, area, or building that has as its primary purpose the sale of foodstuffs requiring additional preparation prior to consumption.

**Hotel function area** is a hotel room or area such as a hotel ballroom, meeting room, exhibit hall or conference room, together with prefunction areas and other spaces ancillary to its function.

**Hotel lobby** is the contiguous spaces in a hotel/motel between the main entrance and the front desk, including waiting and seating areas, and other spaces encompassing the activities normal to a hotel lobby function.

**Kitchen/food preparation** is a room or area with cooking facilities and/or an area where food is prepared.

**Laundry** is a place where laundering activities occur.

**Library** is a repository for literary materials, such as books, periodicals, newspapers, pamphlets and prints, kept for reading or reference.

**Locker/dressing room** is a room or area for changing clothing, sometimes equipped with lockers.

**Lounge/recreation** is a room used for leisure activities which may be associated with a restaurant or bar.

**Main entry lobby/reception/waiting** is the lobby of a building that is directly located by the main entrance of the building and includes the reception area, sitting areas, and public areas.

**Malls, arcades and atria** are public passageways or courtyards that provide access to rows of stores or shops.

**Medical and clinical care** is a room, area, or building that does not provide overnight patient care and that is used to promote the condition of being sound in body or mind through medical, dental, or psychological examination and treatment, including, but not limited to, laboratories and treatment facilities.

**Museum** is a space in which works of artistic, historical, or scientific value are cared for and exhibited.

**Office** is a room, area or building of UBC Group B Occupancy other than restaurants.

**Precision commercial or industrial work** is a room, area, or building in which an art, craft, assembly or a manufacturing operation is performed involving visual tasks of small size or fine detail such as electronic assembly, fine woodworking, metal lathe operation, fine hand painting and finishing, egg processing operations, or tasks of similar visual difficulty.

**Reception/waiting area** is an area where customers or clients are greeted prior to conducting business.

**Religious worship** is a room, area, or building for worship.

**Restaurant** is a room, area, or building that is a food establishment as defined in Section 27520 of the Health and Safety Code.

**Restroom** is a room or suite of rooms providing personal facilities such as toilets and washbasins.

**Retail and sales** is a room, area, or building in which the primary activity is the sale of merchandise.

**School** is a building or group of buildings that is predominately classrooms and that is used by an organization that provides instruction to students.

**Stairs, active/inactive** is a series of steps providing passage from one level of a building to another.

**Support area** is a room or area used as a passageway, utility room, storage space, or other type of space associated with or secondary to the function of an occupancy that is listed in these regulations.

**Theater, motion picture**, is an assembly room, a hall, or a building with tiers of rising seats or steps for the showing of motion pictures.

**Theater, performance**, is an assembly room, a hall, or a building with tiers of rising seats or steps for the viewing of dramatic performances, lectures, musical events and similar live performances.

**Vocational room** is a room used to provide training in a special skill to be pursued as a trade.

**Wholesale showroom** is a room where samples of merchandise are displayed.

**OPERABLE SHADING DEVICE** is a device at the interior or exterior of a building or integral with a fenestration product, which is capable of being operated, either manually or automatically, to adjust the amount of solar radiation admitted to the interior of the building.

**OPTIMAL OVERHANG** is an overhang that completely shades the glazing at solar noon on August 21 and substantially exposes the glass at solar noon on December 21.

**ORNAMENTAL CHANDELIERS** are ceiling-mounted, close-to-ceiling, or suspended decorative luminaires that use glass, crystal, ornamental metals or other decorative material and that typically are used in hotels/motels, restaurants, or churches as significant elements in the interior architecture.

**OUTDOOR AIR (Outside air)** is air taken from outdoors and not previously circulated in the building.

**OVERALL HEAT GAIN** is the value obtained in Section 143 (b) 2 for determining compliance with the component envelope approach.

**OVERALL HEAT LOSS** is the value obtained in Section 143 (b) 1 for determining compliance with the component envelope approach.

**POOR QUALITY LIGHTING TASKS** are visual tasks that require illuminance category E or greater, because of the choice of a writing or printing method that produces characters that are of small size or lower contrast than good quality alternatives that are regularly used in offices.

**PRIVATE OFFICE** or **WORK AREA** is an office bounded by 30-inch or higher partitions and is no more than 200 square feet.

**PROCESS** is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

**PROCESS LOAD** is a load resulting from a process.

**PUBLIC AREAS** are spaces generally open to the public at large, customers or congregation members, or similar spaces where occupants need to be prevented from controlling lights for safety, security or business reasons.

**PUBLIC FACILITY RESTROOM** is a restroom designed for use by the public.

**RADIANT BARRIER** is any reflective material that has an emittance of 0.05 or less, tested in accordance with ASTM C-1371-98 or ASTM E 408-71 (1996) e1, and is certified to the California Department of Consumer Affairs as required by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

**RAISED FLOOR** is a floor (partition) over a crawl space, or an unconditioned space, or ambient air.

**READILY ACCESSIBLE** is capable of being reached quickly for operation, repair or inspection, without requiring climbing or removing obstacles, or resorting to access equipment.

**RECOOL** is the cooling of air that has been previously heated by space-conditioning equipment or systems serving the same building.

**RECOVERED ENERGY** is energy used in a building that (1) is mechanically recovered from space conditioning, service water heating, lighting, or process equipment after the energy has performed its original function; (2) provides space conditioning, service water heating, or lighting; and (3) would otherwise be wasted.

**REDUCED FLICKER OPERATION** is the operation of a light, in which the light has a visual flicker less than 30 percent for frequency and modulation.

**REHEAT** is the heating of air that has been previously cooled by cooling equipment or systems or an economizer.

**RELATIVE SOLAR HEAT GAIN** is the ratio of solar heat gain through a fenestration product (corrected for external shading) to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

**REPAIR** is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance. Note: Repairs to low-rise residential buildings are not within the scope of these standards.

**RESIDENTIAL BUILDING** (See "high-rise residential building" and "low-rise residential building.")

**RESIDENTIAL MANUAL** is the manual developed by the commission, under Section 25402.1 of the Public Resources Code, to aid designers, builders, and contractors in meeting energy efficiency standards for low-rise residential buildings.

**ROOF/CEILING TYPE** is a roof/ceiling assembly having a specific framing type and U-factor.

**ROOM CAVITY RATIO (RCR)** is:

$$(a) \text{ For rectangular rooms } \frac{5H(L + W)}{LW}$$

or

$$(b) \text{ For irregular-shaped rooms } \frac{2.5H \times P}{A}$$

**WHERE:**

$L$  = length of room.

$W$  = width of room.

$H$  = vertical distance from the work plane to the center line of the lighting fixture.

$P$  = perimeter of room.

$A$  = area of room.

**RUNOUT** is piping that is no more than 12 feet long and that is connected to a fixture or an individual terminal unit.

**SCONCE** is a wall-mounted decorative light fixture.

**SEASONAL ENERGY EFFICIENCY RATIO (SEER)** means the total cooling output of a central air conditioner in Btu during its normal usage period for cooling divided by the total electrical energy input in watt-hours during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

**SEMICONDITIONED SPACE** is an enclosed nonresidential space that is provided with wood heating, cooling by direct or indirect evaporation of water, mechanical heating that has a capacity of 10 Btu/(hr · ft<sup>2</sup>) or less, mechanical cooling that has a capacity of 5 Btu/(hr · ft<sup>2</sup>) or less, or is maintained for a process environment as set forth in the definition of "directly conditioned space."

**SERVICE WATER HEATING** is heating of water for sanitary purposes for human occupancy, other than for comfort heating.

**SHADING** is the protection from heat gains because of direct solar radiation by permanently attached exterior devices or building elements, interior shading devices, glazing material, or adherent materials. Permanently attached means (a) attached with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps or ties); or (b) required by the UBC for emergency egress to be removable from the interior without the use of tools.

**SHADING COEFFICIENT (SC)** is the ratio of the solar heat gain through a fenestration product to the solar heat gain through an unshaded 1/8-inch-thick clear double strength glass under the same set of conditions. For nonresidential, high-rise residential and hotel/motel buildings, this shall exclude the effects of mullions, frames, sashes, and interior and exterior shading devices.

**SITE-ASSEMBLED FENESTRATION** includes both field-fabricated fenestration and site-built fenestration.

**SITE-BUILT FENESTRATION PRODUCTS** are fenestration products designed to be field-glazed or field assembled units comprised of specified framing and glazing components. Site-built fenestration is eligible for certification under NFRC 100-SB, and may include both vertical glazing and horizontal glazing.

**SITE SOLAR ENERGY** is natural daylighting, or thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.

**SKYLIGHT** is glazing having a slope less than 60 degrees from the horizontal with conditioned space below.

**SKYLIGHT AREA** is the area of the surface of a skylight, plus the area of the frame, sash and mullions.

**SKYLIGHT TYPE** is a type of skylight assembly having a specific solar heat gain coefficient, and U-factor whether glass mounted on a curb, glass not mounted on a curb or plastic (assumed to be mounted on a curb).

**SOLAR HEAT GAIN COEFFICIENT (SHGC)** is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

**SOURCE ENERGY** is the energy that is used at a site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission and distribution losses, and that is used to perform a specific function, such as space conditioning, lighting or water heating. Table 1-B contains the conversion factors for converting site to source energy.

**SOUTH-FACING** is oriented to within 45 degrees of true south, including 45°00'00" west of south (SW), but excluding 45°00'00" east of south (SE).

**SPA** is a vessel that contains heated water in which humans can immerse themselves, is not a pool, and is not a bathtub.

**SPACE-CONDITIONING SYSTEM** is a system that provides either collectively or individually heating, ventilating, or cooling within or associated with conditioned spaces in a building.

**SMACNA** is the Sheet Metal and Air-conditioning Contractors National Association.

**SYSTEM** is a combination of equipment, controls, accessories, interconnecting means, or terminal elements by which energy is transformed to perform a specific function, such as space conditioning, service water heating, or lighting.

**TASK-ORIENTED LIGHTING** is lighting that is designed specifically to illuminate a task location, and that is generally confined to the task location.

**THERMAL MASS** is solid or liquid material used to store heat for later heating use or for reducing cooling requirements.

**THERMAL RESISTANCE (R)** is the resistance of a material or building component to the passage of heat in (hr. x ft.<sup>2</sup> x °F)/Btu.

**THERMOSTATIC EXPANSION VALVE (TXV)** is a refrigerant metering valve, installed in an air conditioner or heat pump, which controls the flow of liquid refrigerant entering the evaporator in response to the superheat of the gas leaving it.

**THROW DISTANCE** is the distance between the luminaire and the center of the plane lit by the luminaire on a display.

**TUNING** is a lighting control device that allows authorized personnel only to select a single light level within a continuous range.

**UBC** is the 1997 edition of the state-adopted *Uniform Building Code*™.

**UL®** is the Underwriters Laboratories®.

**UMC** is the 1997 edition of the state-adopted *Uniform Mechanical Code*™.

**UNCONDITIONED SPACE** is enclosed space within a building that is not directly conditioned, indirectly conditioned or semi-conditioned space.

**UNIT INTERIOR MASS CAPACITY (UIMC)** is the amount of effective heat capacity per unit of thermal mass, taking into account the type of mass material, thickness, specific heat, density and surface area.

**U-FACTOR** is the overall coefficient of thermal transmittance of a construction assembly, in Btu/(hr. · ft.<sup>2</sup> · °F), including air film resistance at both surfaces.

**VAPOR BARRIER** is a material that has a permeance of one perm or less and that provides resistance to the transmission of water vapor.

**VARIABLE AIR VOLUME (VAV) SYSTEM** is a space-conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served.

**VERTICAL GLAZING** (See “window.”)

**VERY VALUABLE MERCHANDISE** are rare or precious objects, including, but not limited to, jewelry, coins, small art objects, crystal, china, ceramics, or silver, the selling of which involves customer inspection of very fine detail from outside of a locked case.

**VISIBLE LIGHT TRANSMITTANCE (VLT)** is the ratio (expressed as a decimal) of visible light that is transmitted through a glazing material to the light that strikes the material.

**WALL TYPE** is a wall assembly having a specific heat capacity, framing type, and U-factor.

**WELL INDEX** is the ratio of the amount of visible light leaving a skylight well to the amount of visible light entering the skylight well and is calculated as follows:

(a) For rectangular wells:

$$\left( \frac{\text{Well height (well length + well width)}}{2 \times \text{well length} \times \text{well width}} \right)$$

or

(b) For irregular-shaped wells:

$$\left( \frac{\text{Well height} \times \text{well perimeter}}{4 \times \text{well area}} \right)$$

Where the length, width, perimeter, and area are measured at the bottom of the well, and *R* is the weighted average reflectance of the walls of the well.

**WEST-FACING** is oriented to within 45 degrees of true west, including 45°00'00" north of due west (NW), but excluding 45°00'00" south of west (SW).

**WINDOW** is glazing that is not a skylight.

**WINDOW AREA** is the area of the surface of a window, plus the area of the frame, sash, and mullions.

**WINDOW TYPE** is a window assembly having a specific solar heat gain coefficient, relative solar heat gain, and U-factor.

**WINDOW WALL RATIO** is the ratio of the window area to the gross exterior wall area.

**WOOD HEATER** is an enclosed wood-burning appliance used for space heating and/or domestic water heating, and which meets the definition in Federal Register, Volume 52, Number 32, February 18, 1987.

**WOOD STOVE** (See “wood heater.”)

**ZONE, LIGHTING**, is a space or group of spaces within a building that has sufficiently similar requirements so that lighting can be automatically controlled in unison throughout the zone by an illumination-controlling device or devices, and does not exceed one floor.

**ZONE, SPACE-CONDITIONING**, is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in Section 144 (b) 3 or 150 (h), as applicable, can be maintained throughout the zone by a single controlling device.



FIGURE 1-A—CLIMATE ZONES

**SECTION 102 — CALCULATION OF SOURCE ENERGY CONSUMPTION**

When calculating source energy consumption, consumption of electricity, natural gas, fuel oil and LPG shall be converted to Btu at the rates shown in Table 1-B.

**SECTION 103** — Reserved.

**SECTION 104** — Reserved.

**SECTION 105** — Reserved.

**SECTION 106** — Reserved.

**SECTION 107** — Reserved.

**SECTION 108** — Reserved.

**SECTION 109** — Reserved.

**TABLE 1-A—APPLICATION OF STANDARDS**

BUILDING TYPE	MANDATORY	PERFORMANCE	PRESCRIPTIVE	ADDITIONS/ ALTERATIONS
All Occupancies	100 through 109 and 118	—	—	—
Nonresidential, high-rise residential, and hotels/motels				
All	102, 110 through 139	141	142 through 146	149
Envelope	—	141	143	149
Mechanical	120 through 129	141	144 and 145	149
Lighting	130 through 139	141	146	149
Semi-conditioned nonresidential buildings of an occupancy group listed in Section 100	119, 130 through 139	—	146	149 (b) 3
Low-rise residential	102, 110 through 118 and 150	151 (a) through (e)	151 (a), (f)	152

**TABLE 1-B—SOURCE ENERGY CONVERSION RATES**

ENERGY SOURCE	BTU PER UNIT CONSUMPTION
Electricity	10,239 Btu/kilowatt-hour
Natural gas	100,000 Btu/therm
Fuel oil	138,400 Btu/gallon
LPG	91,080 Btu/gallon



## SUBCHAPTER 2

## ALL OCCUPANCIES—MANDATORY REQUIREMENTS FOR THE MANUFACTURE, CONSTRUCTION AND INSTALLATION OF SYSTEMS, EQUIPMENT AND BUILDING COMPONENTS

### SECTION 110 — SYSTEMS AND EQUIPMENT—GENERAL

Sections 111 through 119 establish requirements for the manufacture, construction and installation of certain systems, equipment and building components that are installed in buildings regulated by Title 24, Part 6. Systems, equipment and building components listed below may be installed only if:

(a) The manufacturer has certified that the system, equipment or building component complies with the applicable manufacture provisions of Sections 111 through 119; and

(b) The system, equipment or building component complies with the applicable installation provisions of Sections 111 through 119.

No system, equipment or building component covered by the provisions of Sections 111 through 119 that is not certified or that fails to comply with the applicable installation requirements may be installed in a building regulated by Title 24, Part 6.

The systems, equipment and building components covered are:

Appliances regulated by the Appliance Efficiency Regulations (Section 111).

Other space-conditioning equipment (Section 112).

Other service water-heating systems and equipment (Section 113).

Pool and spa heating systems and equipment (Section 114).

Gas appliances (Section 115).

Doors, windows and fenestration products (Section 116).

Joints and other openings (Section 117).

Insulation and cool roofs (Section 118).

Lighting control devices (Section 119).

### SECTION 111 — MANDATORY REQUIREMENTS FOR APPLIANCES REGULATED BY THE APPLIANCE EFFICIENCY REGULATIONS

Any appliance for which there is a California standard established in the Appliance Efficiency Regulations may be installed only if the manufacturer has certified to the commission, as specified in those regulations, that the appliance complies with the applicable standard for that appliance. See Appendix 1-A for availability of directories of certified appliances.

### SECTION 112 — MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT

**Certification by Manufacturers.** Any space-conditioning equipment listed in this section may be installed only if the manufacturer has certified that the equipment complies with all the applicable requirements of this section.

(a) **Efficiency.** Equipment shall meet the applicable requirements of Tables 1-C1 through 1-C7, subject to the following:

1. If more than one standard is listed in Tables 1-C1 through 1-C7, the equipment shall meet all the standards listed; and

2. If more than one test method is listed in Tables 1-C1 through 1-C7, the equipment shall comply with the applicable standard when tested with each test method; and

3. Where equipment can serve more than one function, such as both heating and cooling, or both space heating and water heating, it shall comply with all the requirements applicable to each function; and

4. Where a requirement is for equipment rated at its “maximum rated capacity” or “minimum rated capacity,” the capacity shall be as provided for and allowed by the controls, during steady-state operation.

5. Dates shown in column headings in Tables 1-C1 through 1-C7 indicate new efficiency levels are required for equipment manufactured on and after October 29, 2001.

**EXCEPTION to Section 112 (a):** Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550 test conditions of 44°F leaving chilled water temperature and 85°F entering condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 1-C8, 1-C9, and 1-C10. The table values are only applicable over the following full load design ranges:

Leaving Chiller Water Temperature	40 to 48°F
Entering Condenser Water Temperature	75 to 85°F
Condensing Water Temperature Rise	5 to 15°F

(b) **Controls for Heat Pumps with Supplementary Electric Resistance Heaters.** Heat pumps with supplementary electric resistance heaters shall have controls:

1. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

2. In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.

**EXCEPTION to Section 112 (b):** The controls may allow supplementary heater operation during:

A. Defrost; and

B. Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

(c) **Gas- and Oil-Fired Furnace Standby Loss Controls.** Gas-fired and oil-fired forced-air furnaces with input ratings  $\geq 225,000$  Btu/hr shall also have an intermittent ignition or interrupted device (IID), and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings  $\geq 225,000$  Btu/hr, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

### SECTION 113 — MANDATORY REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

(a) **Certification by Manufacturers.** Any service water-heating system or equipment may be installed only if the manufacturer

has certified that the system or equipment complies with all of the requirements of this subsection for that system or equipment.

1. **Temperature controls for service water-heating systems.** Service water-heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use as listed in Table 3, Chapter 45 of the 1995 ASHRAE Handbook, HVAC Applications Volume.

**EXCEPTION to Section 113 (a) 1:** Residential occupancies.

(b) **Efficiency.** Equipment shall meet the applicable requirements of Table 1-C11, subject to the following:

1. If more than one standard is listed in Table 1-C11, the equipment shall meet all the standards listed; and

2. If more than one test method is listed in Table 1-C11, the equipment shall comply with the applicable standard when tested with each test method; and

3. Where equipment can serve more than one function, such as both heating and cooling, or both space heating and water heating, it shall comply with all the requirements applicable to each function; and

4. Where a requirement is for equipment rated at its "maximum rated capacity" or "minimum rated capacity," the capacity shall be as provided for and allowed by the controls, during steady-state operation.

5. Dates shown in column headings in Table 1-C11 indicate new efficiency levels are required for equipment manufactured on and after October 29, 2001.

(c) **Installation.** Any service water-heating system or equipment may be installed only if the system or equipment complies with all of the applicable requirements of this subsection for the system or equipment.

1. **Outlet temperature controls.** On systems that have a total capacity greater than 167,000 Btu/hr., outlets that require higher than service water temperatures as listed in the 1995 ASHRAE Handbook, HVAC Applications Volume, shall have separate remote heaters, heat exchangers, or boosters to supply the outlet with the higher temperature.

2. **Pumps for circulating systems.** Circulating service water-heating systems shall have a control capable of automatically turning off the circulating pump when hot water is not required.

**EXCEPTION to Section 113 (c) 2:** Residential occupancies.

3. **Temperature controls for public lavatories.** The controls shall limit the outlet temperature to 110°F.

4. **Insulation.** Unfired service water heater storage tanks and backup tanks for solar water-heating systems shall have:

- A. External insulation with an installed R-value of at least R-12; or
- B. Internal and external insulation with a combined R-value of at least R-16; or
- C. The heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu per hour per square foot.

5. **Service water heaters in state buildings.** Any new building constructed by the State shall derive its service water heating from a system that provides at least 60 percent of the energy needed for service water heating from site solar energy or recovered energy.

**EXCEPTION to Section 113 (c) 5:** Buildings for which the state architect determines that service water heating from site solar energy or recovered energy is economically or physically infeasible.

## SECTION 114 — MANDATORY REQUIREMENTS FOR POOL AND SPA HEATING SYSTEMS AND EQUIPMENT

(a) **Certification by Manufacturers.** Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has all of the following:

1. **Efficiency.** A thermal efficiency for gas-fired systems of at least 78 percent, when tested according to ANSI Standard Z21.56-1994; and

2. **On-off switch.** A readily accessible on-off switch, mounted on the outside of the heater that allows shutting off the heater without adjusting the thermostat setting; and

3. **Instructions.** A permanent, easily readable, and weather-proof plate or card that gives instruction for the energy efficient operation of the pool or spa and for the proper care of pool or spa water when a cover is used; and

4. **Electric resistance heating.** No electric resistance heating; and

**EXCEPTIONS 1 to Section 114 (a) 4:** Listed package units with fully insulated enclosures, and with tight-fitting covers that are insulated to at least R-6.

**EXCEPTION 2 to Section 114 (a) 4:** Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.

5. **Pilot light.** No pilot light.

(b) **Installation.** Any pool or spa heating system or equipment shall be installed with all of the following:

1. **Piping.** At least 36 inches of pipe between the filter and the heater to allow for the future addition of solar heating equipment; and

2. **Covers.** A cover for outdoor pools or outdoor spas; and

**EXCEPTION to Section 114 (b) 2:** Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.

3. **Directional inlets and time switches for pools.** If the system or equipment is for a pool:

A. The pool shall have directional inlets that adequately mix the pool water; and

B. The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

**EXCEPTION to Section 114 (b) 3 B:** Where applicable public health standards require on-peak operation.

## SECTION 115 — NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, AND POOL AND SPA HEATERS: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan-type central furnaces.

(b) Household cooking appliances.

**EXCEPTION to Section 115 (b):** Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

## SECTION 116 — MANDATORY REQUIREMENTS FOR FENESTRATION PRODUCTS AND EXTERIOR DOORS

(a) **Certification of Fenestration Products and Exterior Doors.** Any fenestration product and exterior door, other than

field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the commission, or if an independent certifying organization approved by the commission has certified, that the product complies with all of the applicable requirements of this subsection.

1. **Air leakage.** Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft<sup>2</sup> of window area, 0.3 cfm/ft<sup>2</sup> of door area for residential doors, 0.3 cfm/ft<sup>2</sup> of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft<sup>2</sup> for nonresidential double doors (swinging), when tested according to NFRC-400-95 or ASTM E 283-91 at a pressure differential of 75 pascals or 1.57 pounds/ft<sup>2</sup>, incorporated herein by reference.

2. **U-factor and SHGC.** Fenestration products shall:

- A. Be certified for overall U-factor as rated in accordance with the National Fenestration Rating Council's NFRC 100 (1997) and be certified for overall SHGC, as rated in accordance with the National Fenestration Rating Council's NFRC 200 (1995), incorporated herein by reference, or such values shall be certified in accordance with Tables 1-D and 1-E and labeled as set forth in Section 10-111; and
- B. Have a temporary label or label certificate (for site-built products) meeting the requirements of Section 10-111 (a) 1, not to be removed before inspection by the enforcement agency, listing the certified U-factor and SHGC, and certifying that the air leakage requirements of Section 116 (a) 1 are met for each product line; and
- C. Have a permanent label or label certificate (for site-built products) meeting the requirements of Section 10-111 (a) 2 if the product is rated using NFRC procedures.

**EXCEPTION to Section 116 (a):** Fenestration products removed and reinstalled as part of a building alteration or addition.

**EXCEPTION 1 to Section 116 (a) 2:** Site-assembled vertical glazing in buildings covered by the nonresidential standards with less than 100,000 square feet of conditioned floor area or less than 10,000 square feet of vertical glazing shall have U-factors determined in accordance with NFRC 100-SB procedures or default values set forth in Appendix I of the Nonresidential ACM Manual. Temporary and permanent labels are not required.

**EXCEPTION 2 to Section 116 (a) 2:** Site-assembled vertical glazing in buildings covered by the nonresidential standards shall have SHGC values determined in accordance with NFRC 100-SB procedures or shall calculate the SHGC value for each vertical glazing as:

$$SHGC = 0.08 + 0.86 \times SHGC_c$$

**WHERE:**

$SHGC$  = the solar heat gain coefficient for the fenestration, including glass and frame.

$SHGC_c$  = the center of glass solar heat gain coefficient for the glass alone as documented in the glazing manufacturer's literature. Documentation shall be provided as set forth in Appendix I of the Nonresidential ACM Manual.

**EXCEPTION 3 to Section 116 (a) 2:** Skylights and site-assembled horizontal glazing shall have SHGC values and U-factors determined in accordance with NFRC procedures or default values set forth in Appendix I of the Nonresidential ACM Manual. Documentation shall be provided as set forth in Appendix I of the Nonresidential ACM Manual.

(b) **Installation of Field-fabricated Fenestration Products and Exterior Doors.** Field-fabricated fenestration products and exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weatherstripped.

**EXCEPTION to Section 116 (b):** Unframed glass doors and fire doors.

## SECTION 117 — MANDATORY REQUIREMENTS FOR JOINTS AND OTHER OPENINGS

Joints and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weatherstripped, or otherwise sealed to limit infiltration and exfiltration.

## SECTION 118 — MANDATORY REQUIREMENTS FOR INSULATION AND COOL ROOFS

(a) **Certification by Manufacturers.** Any insulation of the type and form listed below may be installed only if the manufacturer has certified that the insulation complies with the California Code of Regulations, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material. See Appendix 1-A for availability of directories of certified insulating material.

TYPE	FORM
Aluminum foil	Reflective foil
Cellular glass	Board form
Cellulose fiber	Loose fill and spray applied
Mineral aggregate	Board form
Mineral fiber	Blankets, board form, loose fill
Perlite	Loose fill
Phenolic	Board form
Polystyrene	Board form, molded extruded
Polyurethane	Board form and field applied
Polyisocyanurate	Board form and field applied
Urea formaldehyde	Foam field applied
Vermiculite	Loose fill

(b) **Installation of Urea Formaldehyde Foam Insulation.** Urea formaldehyde foam insulation may be applied or installed only if:

1. It is installed in exterior side walls; and
2. A 4-mil-thick plastic polyethylene vapor barrier or equivalent plastic sheeting vapor barrier is installed between the urea formaldehyde foam insulation and the interior space in all applications.

(c) **Flamespread Rating.** All insulating material shall be installed in compliance with the flamespread rating and smoke density requirements of Section 707 of the UBC.

(d) **Installation of Insulation in Existing Buildings.** Insulation installed in an existing attic, or on an existing duct or water heater, shall comply with the applicable requirements of this subsection. If a contractor installs the insulation, the contractor shall certify to the customer, in writing, that the insulation meets the applicable requirements of this subsection.

1. **Attics.** If insulation is installed in the existing attic of a low-rise residential building, the R-value of the total amount of insulation (after addition of insulation to the amount, if any, already in the attic) shall be at least R-30 if the building is located in an area that has less than 5,000 heating degree days, or R-38 if the building is located in an area that has 5,000 heating degree days or more.

**EXCEPTION to Section 118 (d) 1:** Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation provided such installation does not violate Section 1505.3 of Title 24, Part 2.

2. **Water heaters.** If external insulation is installed on an existing unfired water storage tank or on an existing back-up tank for a solar water-heating system, it shall have an R-value of at least R-12, or the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu per hour per square foot.

3. **Ducts.** If insulation is installed on an existing space-conditioning duct, it shall comply with Section 604 of the CMC<sup>1</sup>.

(e) **Demising Walls in Nonresidential Buildings.** The opaque portions of framed demising walls in nonresidential buildings shall have insulation with an installed R-value of no less than R-11 between framing members.

(f) **Mandatory Requirements for Cool Roofs.** Effective January 1, 2003, a roof shall be considered a cool roof if the roofing product is certified and labeled according to requirements of Section 10-113 and if the roofing product meets condition 1 or 2 and, for liquid-applied roofing products, condition 3 below. Prior to January 1, 2003, manufacturer's published performance data shall be acceptable to show compliance with condition 1 or 2 and, for liquid-applied roofing products, condition 3 below.

1. Concrete tile (as defined in ASTM C 55-99) and clay tile (as defined in ASTM C 1167-96) roofing products shall have a minimum initial total solar reflectance of 0.40 when tested in accordance with ASTM E 903 or E 1918, and a minimum thermal emittance of 0.75 when tested in accordance with ASTM E 408.

2. All other roofing products shall have a minimum initial total solar reflectance of 0.70 when tested in accordance with ASTM E 903 or E 1918, and a minimum thermal emittance of 0.75 when tested in accordance with ASTM E 408.

3. Liquid-applied roofing products shall be applied at a minimum dry mil thickness of 20 mils across the entire roof surface, and meet the minimum performance requirements of ASTM D6083-97 when tested in accordance with ASTM D 6083-97 for the following key properties:

- A. Initial Tensile Strength
- B. Initial Elongation
- C. Elongation after 1,000 Hours Accelerated Weathering
- D. Permeance
- E. Accelerated Weathering

## SECTION 119 — MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES

Any automatic time switch control device, occupant-sensing device, automatic daylighting control device, or interior photocell sensor device may be installed only if the manufacturer has certified to the commission that the device complies with all of the applicable requirements of Subsections (a) through (g), and if the device is installed in compliance with Subsection (h).

(a) **All Devices: Instructions for Installation and Calibration.** The manufacturer shall provide step-by-step instructions for installation and start-up calibration of the device.

(b) **All Devices: Status Signal.** The device shall have an indicator that visibly or audibly informs the device operator that it is operating properly, or that it has failed or malfunctioned.

**EXCEPTION to Section 119 (b):** Photocell sensors or other devices where a status signal is infeasible because of inadequate power.

(c) **Automatic Time Switch Control Devices.** Automatic time switch control devices shall:

1. Be capable of programming different schedules for weekdays and weekends; and

2. Have program backup capabilities that prevent the loss of the device's program and time setting for at least 10 hours if power is interrupted.

(d) **Occupant-sensing Devices.** Occupant-sensing devices shall be capable of automatically turning off all the lights in an area no more than 30 minutes after the area has been vacated. In addition, ultrasonic and microwave devices shall have a built-in mechanism that allows calibration of the sensitivity of the device to room movement in order to reduce the false sensing of occupants, and shall comply with either Item 1 or 2 below, as applicable:

1. If the device emits ultrasonic radiation as a signal for sensing occupants within an area, the device shall:

- A. Have had a Radiation Safety Abbreviated Report submitted to the Center for Devices and Radiological Health, Federal Food and Drug Administration, under 21 Code of Federal Regulations, Section 1002.12 (1996), and a copy of the report shall have been submitted to the California Energy Commission; and
- B. Emit no audible sound; and
- C. Not emit ultrasound in excess of the following decibel (dB) values, measured no more than 5 feet from the source, on axis:

MIDFREQUENCY OF SOUND PRESSURE THIRD-OCTAVE BAND (in kHz)	MAXIMUM dB LEVEL WITHIN THIRD-OCTAVE BAND (in dB reference 20 micropascals)
Less than 20	80
20 or more to less than 25	105
25 or more to less than 31.5	110
31.5 or more	115

2. If the device emits microwave radiation as a signal for sensing occupants within the area, the device shall:

- A. Comply with all applicable provisions in 47 Code of Federal Regulations, Parts 2 and 15 (1996), and have an approved Federal Communications Commission Identifier that appears on all units of the device and that has been submitted to the commission; and
- B. Not emit radiation in excess of 1 milliwatt per square centimeter measured at no more than 5 centimeters from the emission surface of the device; and
- C. Have permanently affixed to it installation instructions recommending that it be installed at least 12 inches from any area normally used by room occupants.

(e) **Automatic Daylighting Control Devices.** Automatic daylighting control devices shall:

- 1. Be capable of reducing the light output of the general lighting of the controlled area by at least one half while maintaining a uniform level of illuminance throughout the area; and
- 2. If the device is a dimmer, provide electrical outputs to lamps for reduced flicker operation through the dimming range and without causing premature lamp failure; and
- 3. If the device is a stepped dimming system, incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes; and
- 4. If the device uses step switching with separate on and off settings for the steps, have sufficient separation (deadband) of on and off points to prevent cycling; and

<sup>1</sup>On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct insulation shall comply with Section 605 of the 2000 CMC.

5. Have provided by the manufacturer step-by-step instructions for installation and start-up calibration to design footcandle levels.

(f) **Interior Photocell Sensor Devices.** Interior photocell sensors shall not have a mechanical slide cover or other device that permits easy unauthorized disabling of the control, and shall not be incorporated into a wall-mounted occupant-sensing device.

(g) **Installation in Accordance with Manufacturer's Instructions.** If an automatic time switch control device, occupant-sensing device, automatic daylighting control device, or interior photocell sensor device is installed, it shall comply with both Items 1 and 2 below.

1. The device shall be installed in accordance with the manufacturer's instructions; and

2. Automatic daylighting control devices shall:

- A. Be installed so that automatic daylighting control devices control only luminaires within the daylit area; and
- B. Have photocell sensors that are either ceiling mounted or located so that they are accessible only to authorized personnel, and that are located so that they maintain adequate illumination in the area according to the designer's or manufacturer's instructions.

**TABLE 1-C1—ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS —  
MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	EFFICIENCY PRIOR TO 10/29/2001 <sup>1</sup>	EFFICIENCY AS OF 10/29/2001 <sup>1</sup>	TEST PROCEDURE
Air conditioners, air cooled	≥65,000 Btu/hr and < 135,000 Btu/hr	8.9 EER and 8.3 IPLV	10.3 EER <sup>2</sup>	ARI 210/240
	≥135,000 Btu/hr and < 240,000 Btu/hr	8.5 EER and 7.5 IPLV	9.7 EER <sup>2</sup>	ARI 340/360
	≥ 240,000 Btu/hr and <760,000 Btu/hr	8.5 EER and 7.5 IPLV	9.5 EER <sup>2</sup> and 9.7 IPLV <sup>2</sup>	
	≥760,000 Btu/hr	8.2 EER and 7.5 IPLV	9.2 EER <sup>2</sup> and 9.4 IPLV <sup>2</sup>	
Air conditioners, water and evaporatively cooled	> 65,000 Btu/hr and < 135,000 Btu/hr	10.5 EER and 9.7 IPLV	11.5 EER <sup>2</sup>	ARI 210/240
	≥135,000 Btu/hr and ≤240,000 Btu/hr	9.6 EER and 9.0 IPLV	11.0 EER <sup>2</sup>	ARI 340/360
	> 240,000 Btu/hr	9.6 EER and 9.0 IPLV	11.0 EER <sup>2</sup> and 10.3 IPLV <sup>2</sup>	
Condensing units, air cooled	≥135,000 Btu/hr	9.9 EER and 11.0 IPLV	10.1 EER and 11.2 IPLV	ARI 365
Condensing units, water or evaporatively cooled	≥135,000 Btu/hr	12.9 EER and 12.9 IPLV	13.1 EER and 13.1 IPLV	

<sup>1</sup>IPLVs are applicable only to equipment with capacity modulation.

<sup>2</sup>Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

TABLE 1-C2—UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED — MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	EFFICIENCY PRIOR TO 10/29/2001	EFFICIENCY AS OF 10/29/2001 <sup>1</sup>	TEST PROCEDURE
Air cooled (cooling mode)	≥65,000 Btu/hr and < 135,000 Btu/hr	Split system and single package	8.9 EER 8.3 IPLV	10.1 EER <sup>2</sup>	ARI 210/240
	≥135,000 Btu/hr and <240,000 Btu/hr	Split system and single package	8.5 EER 7.5 IPLV	9.3 EER <sup>2</sup>	ARI 340/360
	≥240,000 Btu/hr and <760,000 Btu/hr	Split system and single package	8.5 EER 7.5 IPLV	9.0 EER <sup>2</sup> 9.2 IPLV <sup>2</sup>	
	≥760,000 Btu/hr	Split system and single package	8.2 EER 7.5 IPLV	9.0 EER <sup>2</sup> 9.2 IPLV <sup>2</sup>	
Water-source (cooling mode)	< 17,000 Btu/hr	85°F entering water	10.0 EER		ARI 320
		86°F entering water		11.2 EER	ARI/ISO-13256-1
	≥ 17,000 Btu/hr and <65,000 Btu/hr	85°F entering water	10.0 EER		ARI 320
		86°F entering water		12.0 EER	ARI/ISO-13256-1
	≥65,000 Btu/hr and < 135,000 Btu/hr	85°F entering water	10.5 EER		ARI 320
		86°F entering water		12.0 EER	ARI/ISO-13256-1
Groundwater-source (cooling mode)	< 135,000 Btu/hr	70°F entering water	11.0 EER		ARI 325
		59°F entering water		16.2 EER	ARI/ISO-13256-1
Ground source (cooling mode)	< 135,000 Btu/hr	77°F entering water	N/A	13.4 EER	ARI/ISO-13256-1
Air cooled (heating mode)	≥65,000 Btu/hr and < 135,000 Btu/hr (cooling capacity)	47°F db/43°F wb outdoor air	3.0 COP	3.2 COP	ARI 210/240
	≥135,000 Btu/hr (cooling capacity)	47°F db/43°F wb outdoor air	2.9 COP	3.1 COP	ARI 340/360
Water-source (heating mode)	< 135,000 Btu/hr (cooling capacity)	70°F entering water	3.8 COP		ARI 320
		68°F entering water		4.2 COP	ARI/ISO-13256-1
Groundwater-source (heating mode)	< 135,000 Btu/hr (cooling capacity)	70°F entering water	3.5 COP		ARI 325
		50°F entering water		3.6 COP	ARI/ISO-13256-1
Ground source (heating mode)	< 135,000 Btu/hr (cooling capacity)	32°F entering water	N/A	3.1 COP	ARI/ISO-13256-1

<sup>1</sup>IPLVs and Part load rating conditions are applicable only to equipment with capacity modulation.<sup>2</sup>Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

TABLE 1-C3—WATER CHILLING PACKAGES — MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	EFFICIENCY PRIOR TO 10/29/2001	EFFICIENCY AS OF 10/29/2001	TEST PROCEDURE
Air cooled, with condenser, electrically operated	< 150 tons	2.70 COP 2.80 IPLV	2.80 COP 2.80 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 tons	2.50 COP 2.50 IPLV		
Air cooled, without condenser, electrically operated	All capacities	3.10 COP 3.20 IPLV	3.10 COP 3.10 IPLV	
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	3.80 COP 3.90 IPLV	4.20 COP 4.65 IPLV	ARI 590
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	3.80 COP 3.90 IPLV	4.45 COP 4.50 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 tons and < 300 tons	4.20 COP 4.50 IPLV	4.90 COP 4.95 IPLV	
	≥300 tons —	5.20 COP 5.30 IPLV	5.50 COP 5.60 IPLV	
Water cooled, electrically operated, centrifugal	< 150 tons	3.80 COP 3.90 IPLV	5.00 COP 5.00 IPLV	ARI 550
	≥150 tons and < 300 tons	4.20 COP 4.50 IPLV	5.55 COP 5.55 IPLV	
	≥300 tons —	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV	
Air cooled absorption single effect	All capacities	N/A	0.60 COP	ARI 560
Water cooled absorption single effect	All capacities	N/A	0.70 COP	
Absorption double effect, indirect-fired	All capacities	N/A N/A	1.00 COP 1.05 IPLV	
Absorption double effect, direct-fired	All capacities	N/A N/A	1.00 COP 1.00 IPLV	

TABLE 1-C4—PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS — MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY (Input)	SUBCATEGORY OR RATING CONDITION	EFFICIENCY PRIOR TO 10/29/2001 <sup>1</sup>	EFFICIENCY AS OF 10/29/2001 <sup>1</sup>	TEST PROCEDURE
PTAC (cooling mode) new construction	All capacities	95°F db outdoor air	10.0 - (0.16 x Cap/1000) <sup>1</sup> EER	12.5 - (0.213 x Cap/1000) <sup>1</sup> EER	ARI 310/380
PTAC (cooling mode) replacements <sup>2</sup>	All capacities	95°F db outdoor air	10.0 - (0.16 x Cap/1000) <sup>1</sup> EER	10.9 - (0.213 x Cap/1000) <sup>1</sup> EER	
PTHP (cooling mode) new construction	All capacities	95°F db outdoor air	10.0 - (0.16 x Cap/1000) <sup>1</sup> EER	12.3 - (0.213 x Cap/1000) <sup>1</sup> EER	
PTHP (cooling mode) replacements <sup>2</sup>	All capacities	95°F db outdoor air	10.0 - (0.16 x Cap/1000) <sup>1</sup> EER	10.8 - (0.213 x Cap/1000) <sup>1</sup> EER	
PTHP (heating mode) new construction	All capacities		2.9 - (0.026 x Cap/1000) <sup>1</sup> COP	3.2 - (0.026 x Cap/1000) <sup>1</sup> COP	
PTHP (heating mode) replacements <sup>2</sup>	All capacities		2.9 - (0.026 x Cap/1000) <sup>1</sup> COP	2.9 - (0.026 x Cap/1000) <sup>1</sup> COP	

<sup>1</sup>Cap means the rated cooling capacity of the product in Btu/hr. If the unit's capacity is less than 7000 Btu/hr, use 7000 Btu/hr in the calculation. If the unit's capacity is greater than 15,000 Btu/hr, use 15,000 Btu/hr in the calculation.

<sup>2</sup>Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches high and less than 42 inches wide.

**TABLE 1-C5—WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS,  
WARM-AIR DUCT FURNACES AND UNIT HEATERS — MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY (Input)	SUBCATEGORY OR RATING CONDITION	EFFICIENCY PRIOR TO 10/29/2001 <sup>1</sup>	EFFICIENCY AS OF 10/29/2001	TEST PROCEDURE
Warm-air furnace, gas-fired	≥225,000 Btu/hr	Maximum capacity Minimum capacity <sup>3</sup>	80% E <sub>t</sub> 78% E <sub>t</sub>	80% E <sub>c</sub> <sup>2</sup>	ANSI Z21.47
Warm-air furnace, oil-fired	≥225,000 Btu/hr	Maximum capacity Minimum capacity <sup>3</sup>	81% E <sub>t</sub> 81% E <sub>t</sub>	81% E <sub>t</sub> <sup>1</sup>	UL 727
Warm-air duct furnaces, gas-fired	All capacities	Maximum capacity Minimum capacity <sup>3</sup>	80% E <sub>t</sub> 75% E <sub>t</sub>	80% E <sub>c</sub> <sup>2</sup>	ANSI Z83.9
Warm-air unit heaters, gas-fired	All capacities	Maximum capacity Minimum capacity <sup>3</sup>	80% E <sub>t</sub> 74% E <sub>t</sub>	80% E <sub>c</sub> <sup>2</sup>	ANSI Z83.8
Warm-air unit heaters, oil-fired	All capacities	Maximum capacity Minimum capacity <sup>3</sup>	81% E <sub>t</sub> 81% E <sub>t</sub>	80% E <sub>c</sub> <sup>2</sup>	UL 731

<sup>1</sup>E<sub>t</sub> = Thermal efficiency. See test procedure for detailed discussion.<sup>2</sup>E<sub>c</sub> = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.<sup>3</sup>Minimum ratings as provided for and allowed by unit's controls.**TABLE 1-C6—BOILERS, GAS- AND OIL-FIRED — MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE <sup>5</sup>	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	EFFICIENCY PRIOR TO 10/29/2001 <sup>4</sup>	EFFICIENCY AS OF 10/29/2001	TEST PROCEDURE
Boilers, gas-fired	≥300,000 Btu/hr and ≤ 2,500,000 Btu/hr	Maximum capacity <sup>1</sup> Minimum capacity <sup>1</sup>	80% E <sub>c</sub> <sup>2</sup> 80% E <sub>c</sub> <sup>2</sup>	75% E <sub>t</sub> <sup>3</sup>	H.I. Htg Boiler Standard
	> 2,500,000 Btu/hr <sup>5</sup>	Hot water	80% E <sub>c</sub> <sup>2</sup>	80% E <sub>c</sub> <sup>2</sup>	
	> 2,500,000 Btu/hr <sup>5</sup>	Steam	80% E <sub>c</sub> <sup>2</sup>	80% E <sub>c</sub> <sup>2</sup>	
Boilers, oil-fired	≥300,000 Btu/hr and ≤ 2,500,000 Btu/hr	Maximum capacity <sup>1</sup> Minimum capacity <sup>1</sup>	83% E <sub>c</sub> <sup>2</sup> 83% E <sub>c</sub> <sup>2</sup>	78% E <sub>t</sub> <sup>3</sup>	H.I. Htg Boiler Standard
	> 2,500,000 Btu/hr <sup>5</sup>	Hot water	83% E <sub>c</sub> <sup>2</sup>	83% E <sub>c</sub> <sup>2</sup>	
	> 2,500,000 Btu/hr <sup>5</sup>	Steam	83% E <sub>c</sub> <sup>2</sup>	83% E <sub>c</sub> <sup>2</sup>	
Oil-fired (residual)	≥300,000 Btu/hr and ≤ 2,500,000 Btu/hr	Maximum capacity <sup>1</sup> Minimum capacity <sup>1</sup>	83% E <sub>c</sub> <sup>2</sup> 83% E <sub>c</sub> <sup>2</sup>	78% E <sub>t</sub> <sup>3</sup>	H.I. Htg Boiler Standard
	> 2,500,000 Btu/hr <sup>5</sup>	Hot water	83% E <sub>c</sub> <sup>2</sup>	83% E <sub>c</sub> <sup>2</sup>	
	> 2,500,000 Btu/hr <sup>5</sup>	Steam	83% E <sub>c</sub> <sup>2</sup>	83% E <sub>c</sub> <sup>2</sup>	

<sup>1</sup>Minimum and maximum ratings as provided for and allowed by the unit's controls.<sup>2</sup>E<sub>c</sub> = Combustion efficiency (100% less flue losses). See test procedure for detailed information.<sup>3</sup>E<sub>t</sub> = Thermal efficiency. See test procedure for detailed information.<sup>4</sup>Alternate test procedures used at the manufacturer's option are ASME PTC-4.1 for units over 5,000,000 Btu/hr input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/hr and less than or equal to 2,500,000 Btu/hr input.<sup>5</sup>These requirements apply to boilers with rated input of 8,000,000 Btu/hr or less that are not packaged boilers, and to all packaged boilers**TABLE 1-C7—PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT**

EQUIPMENT TYPE	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED AS OF 10/29/2001 <sup>1, 2</sup>	TEST PROCEDURE
Propeller or axial fan cooling towers	All	95°F entering water 85°F leaving water 78°F wb outdoor air	≥38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan cooling towers	All	95°F entering water 85°F leaving water 78°F wb outdoor air	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Air-cooled condensers	All	125°F condensing temperature R22 test fluid 190°F entering gas temperature 15°F subcooling 95°F entering drybulb	≥176,000 Btu/hr-hp	ARI 460

<sup>1</sup>For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.<sup>2</sup>For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

TABLE 1-C8—COPS AND IPLVS FOR NONSTANDARD CENTRIFUGAL CHILLERS &lt; 150 TONS

CENTRIFUGAL CHILLERS < 150 Tons COP <sub>std</sub> = 5.4								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT <sup>1</sup> (°F)	Required COP and IPLV (IPLV=COP)					
46	75	29	6.00	6.27	6.48	6.80	7.03	7.20
45	75	30	5.92	6.17	6.37	6.66	6.87	7.02
44	75	31	5.84	6.08	6.26	6.53	6.71	6.86
43	75	32	5.75	5.99	6.16	6.40	6.58	6.71
42	75	33	5.67	5.90	6.06	6.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
40	75	35	5.50	5.74	5.89	6.10	6.23	6.33
46	80	34	5.59	5.82	5.98	6.19	6.34	6.44
45	80	35	5.50	5.74	5.89	6.10	6.23	6.33
44	80	36	5.41	5.66	5.81	6.01	6.13	6.22
43	80	37	5.31	5.57	5.73	5.92	6.04	6.13
42	80	38	5.21	5.48	5.64	5.84	5.95	6.04
41	80	39	5.09	5.39	5.56	5.76	5.87	5.95
40	80	40	4.96	5.29	5.47	5.67	5.79	5.86
46	85	39	5.09	5.39	5.56	5.76	5.87	5.95
45	85	40	4.96	5.29	5.47	5.67	5.79	5.86
44	85	41	4.83	5.18	5.40	5.59	5.71	5.78
43	85	42	4.68	5.07	5.28	5.50	5.62	5.70
42	85	43	4.51	4.94	5.17	5.41	5.54	5.62
41	85	44	4.33	4.80	5.05	5.31	5.45	5.53
40	85	45	4.13	4.65	4.92	5.21	5.35	5.44
Condenser DT <sup>2</sup>			14.04	11.23	9.36	7.02	5.62	4.68

<sup>1</sup>LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature<sup>2</sup>Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Condenser DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

TABLE 1-C9—COPS AND IPLVS FOR NONSTANDARD CENTRIFUGAL CHILLERS &gt; 150 TONS, ≤ 300 TONS

CENTRIFUGAL CHILLERS > 150 Tons, ≤ 300 Tons COP <sub>std</sub> = 5.55								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT <sup>1</sup> (°F)	Required COP and IPLV (IPLV=COP)					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.9	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser DT <sup>2</sup>			14.04	11.23	9.36	7.02	5.62	4.68

<sup>1</sup>LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature<sup>2</sup>Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Condenser DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

TABLE 1-C10—COPS AND IPLVS FOR NONSTANDARD CENTRIFUGAL CHILLERS &gt; 300 TONS

CENTRIFUGAL CHILLERS > 300 Tons COP <sub>std</sub> = 6.1								
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT <sup>1</sup> (°F)	Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP and IPLV (IPLV=COP)					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser DT <sup>2</sup>			14.04	11.23	9.36	7.02	5.62	4.68

<sup>1</sup>LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature<sup>2</sup>Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Condenser DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

TABLE 1-C11—MINIMUM EFFICIENCY REQUIREMENTS FOR WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED PRIOR TO 10/29/2001 <sup>1</sup>	PERFORMANCE REQUIRED AS OF 10/29/2001 <sup>2</sup>	TEST PROCEDURE
Gas storage water heaters	> 75,000 Btu/hr and ≤ 155,000 Btu/hr	< 4,000 Btu/hr/gal	$78\% E_t$ $7.47V + 655 SL$ , Btu/hr	$80\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	ANSI Z21.10.3
	> 155,000 Btu/hr	< 4,000 Btu/hr/gal	$78\% E_t$ $7.47V + 546 SL$ , Btu/hr	$80\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	
Gas instantaneous water heaters	> 200,000 Btu/hr <sup>3</sup>	≥ 4,000 Btu/hr/gal and < 10 gal	$80\% E_t$	$80\% E_t$	ANSI Z21.10.3
	> 200,000 Btu/hr <sup>3</sup>	≥ 4,000 Btu/hr/gal and ≥ 10 gal	$77\% E_t$ $13.22V + 385 SL$ , Btu/hr	$80\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	
Oil storage water heaters	> 105,000 Btu/hr and ≤ 155,000 Btu/hr	< 4,000 Btu/hr/gal	$78\% E_t$ $7.47V + 655 SL$ , Btu/hr	$78\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	ANSI Z21.10.3
	> 155,000 Btu/hr	< 4,000 Btu/hr/gal	$78\% E_t$ $7.47V + 546 SL$ , Btu/hr	$78\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	
Oil instantaneous water heaters	> 210,000 Btu/hr <sup>3</sup>	≥ 4,000 Btu/hr/gal and < 10 gal	$80\% E_t$	$80\% E_t$	ANSI Z21.10.3
	> 210,000 Btu/hr <sup>3</sup>	≥ 4,000 Btu/hr/gal and ≥ 10 gal	$77\% E_t$ $13.22V + 385 SL$ , Btu/hr	$78\% E_t$ $(Q/800 + 110\sqrt{V}) SL$ , Btu/hr	

<sup>1</sup>Thermal efficiency ( $E_t$ ) is a minimum requirement, while standby loss ( $SL$ ) is a maximum Btu/hr based on a 70°F temperature difference between stored water and ambient requirements. In the  $SL$  equation,  $V$  is the measured volume in gallons.

<sup>2</sup>Thermal efficiency ( $E_t$ ) is a minimum requirement, while standby loss ( $SL$ ) is a maximum Btu/hr based on a 70° temperature difference between stored water and ambient requirements. In the  $SL$  equation,  $V$  is the rated volume in gallons and  $Q$  is the nameplate input rate in Btu/hr.

<sup>3</sup>Instantaneous water heaters with input rates below 200,000 Btu/hr must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

TABLE 1-D—DEFAULT FENESTRATION PRODUCT U-FACTORS

FRAME TYPE <sup>1</sup>	PRODUCT TYPE	SINGLE PANE U-FACTOR	DOUBLE PANE U-FACTOR <sup>2</sup>
Metal	Operable	1.28	0.87
Metal	Fixed	1.19	0.72
Metal	Greenhouse/garden window	2.26	1.40
Metal	Doors	1.25	0.85
Metal	Skylight	1.72	0.94
Metal, Thermal Break	Operable		0.71
Metal, Thermal Break	Fixed		0.60
Metal, Thermal Break	Greenhouse/garden window		1.12
Metal, Thermal Break	Doors		0.64
Metal, Thermal Break	Skylight		0.80
Nonmetal	Operable	0.99	0.60
Nonmetal	Fixed	1.04	0.57
Nonmetal	Doors	0.99	0.55
Nonmetal	Greenhouse/garden window	1.94	1.06
Nonmetal	Skylight	1.47	0.68

<sup>1</sup>Metal includes any field-fabricated product with metal cladding. Nonmetal-framed manufactured fenestration products with metal cladding must add 0.04 to the listed U-factor. Nonmetal frame types can include metal fasteners, hardware, and door thresholds. Thermal break product design characteristics are:

- The material used as the thermal break must have a thermal conductivity of not more than 3.6 Btu-inch/hr/ft<sup>2</sup>/°F,
  - The thermal break must produce a gap of not less than 0.210 inch, and
  - All metal members of the fenestration product exposed to interior and exterior air must incorporate a thermal break meeting the criteria in a. and b. above.
- In addition, the fenestration product must be clearly labeled by the manufacturer that it qualifies as a thermally broken product in accordance with this standard.

<sup>2</sup>For all dual-glazed fenestration products, adjust the listed U-factors as follows:

- Subtract 0.05 for spacers of  $\frac{7}{16}$  inch or wider.
- Subtract 0.05 for products certified by the manufacturer as low-E glazing.
- Add 0.05 for products with dividers between panes if spacer is less than  $\frac{7}{16}$  inch wide.
- Add 0.05 to any product with true divided lite (dividers through the panes).

TABLE 1-E—DEFAULT SOLAR HEAT GAIN COEFFICIENT

FRAME TYPE	PRODUCT	GLAZING	TOTAL WINDOW SHGC	
			Single Pane	Double Pane
Metal	Operable	Clear	0.80	0.70
Metal	Fixed	Clear	0.83	0.73
Metal	Operable	Tinted	0.67	0.59
Metal	Fixed	Tinted	0.68	0.60
Metal, Thermal Break	Operable	Clear	0.72	0.63
Metal, Thermal Break	Fixed	Clear	0.78	0.69
Metal, Thermal Break	Operable	Tinted	0.60	0.53
Metal, Thermal Break	Fixed	Tinted	0.65	0.57
Nonmetal	Operable	Clear	0.74	0.65
Nonmetal	Fixed	Clear	0.76	0.67
Nonmetal	Operable	Tinted	0.60	0.53
Nonmetal	Fixed	Tinted	0.63	0.55

SHGC = Solar Heat Gain Coefficient



## SUBCHAPTER 3

### NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES—MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING AND SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

#### SECTION 120 — SPACE-CONDITIONING AND SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT—GENERAL

Sections 121 through 129 establish requirements for the design and installation of space-conditioning and service water-heating systems and equipment in nonresidential, high-rise residential, and hotel/motel buildings subject to Title 24, Part 6. All such buildings shall comply with the applicable provisions of Sections 121 through 129.

#### SECTION 121 — REQUIREMENTS FOR VENTILATION

##### (a) General Requirements.

1. All enclosed spaces in a building that are normally used by humans shall be ventilated in accordance with the requirements of this section.

**NOTE:** In addition to meeting the requirements of this section, for those occupancies where unusual contaminants are present or anticipated (such as commercial dry cleaners, coin-operated dry cleaners, bars and cocktail lounges, auto repair workshops, smoking lounges, barber shops, beauty shops), it is recommended to use local exhaust ventilation and enclosure to capture the contaminants and discharge them directly outdoors.

2. The outdoor air-ventilation rate and air-distribution assumptions made in the design of the ventilating system shall be clearly identified on the plans required by Section 10-103 of Title 24, Part 1.

**(b) Design Requirements for Minimum Quantities of Outdoor Air.** Every space in a building shall be designed to have outdoor air ventilation according to Item 1 or 2 below:

1. **Natural ventilation.** Natural ventilation may be provided for spaces that:

- A. Are within 20 feet of an operable wall or roof opening through which outdoor air flows, which has an operable area more than 5 percent of the conditioned floor area of the space, and which is readily accessible to occupants of the space at all times when the space is occupied; and
- B. Have a direct outdoor airflow from the operable wall or roof opening, unobstructed by walls or doors.

2. **Mechanical ventilation.** Each space that is not naturally ventilated under Item 1 above shall be ventilated with a mechanical system capable of providing an outdoor air rate no less than the larger of:

- A. The conditioned floor area of the space times the applicable ventilation rate from Table 1-F; or
- B. Fifteen cfm per person times the expected number of occupants. For spaces without fixed seating, the expected number of occupants shall be assumed to be no less than one half the maximum occupant load assumed for exiting purposes in Chapter 10 of the UBC. For spaces with fixed seating, the expected number of occupants shall be determined in accordance with Chapter 10 of the UBC.

**EXCEPTION to Section 121 (b) 2:** Transfer air. The rate of outdoor air required by Section 121 (b) 2 may be provided with air transferred from other ventilated spaces if:

- A. None of the spaces from which air is transferred have any unusual sources of indoor air contaminants; and
- B. Enough outdoor air is supplied to all spaces combined to meet the requirements of Section 121 (b) 2 for each space individually.

##### (c) Operation and Control Requirements for Minimum Quantities of Outdoor Air.

1. **Times of occupancy.** The minimum rate of outdoor air required by Section 121 (b) 2 shall be supplied to each space at all times when the space is usually occupied.

**EXCEPTION 1 to Section 121 (c) 1:** Demand control ventilation. The rate of outdoor air provided to an intermittently occupied space may be reduced to 0.15 cfm per square foot of conditioned floor area if the ventilation system serving the space is controlled by a demand control ventilation device complying with Section 121 (c) 4.

**EXCEPTION 2 to Section 121 (c) 1:** Temporary reduction. The rate of outdoor air provided to a space may be reduced below the level required by Section 121 (b) 2 for up to five minutes each hour if the average rate each hour is the required rate.

2. **Pre-occupancy.** The lesser of the minimum rate of outdoor air required by Section 121 (b) 2 or three complete air changes shall be supplied to the entire building during the one-hour period immediately before the building is normally occupied.

3. **Required demand control ventilation.** HVAC systems with the following characteristics shall have demand ventilation controls complying with Section 121 (c) 4:

- A. That primarily serve areas with fixed seating and occupant densities less than or equal to 10 square feet per person, or identified in Chapter 10 of the UBC as either “assembly areas, concentrated use (without fixed seats)” or “auction rooms”; and
- B. That have design outdoor air capacities equal to or exceeding 3,000 cfm.

4. Demand control ventilation devices shall:

- A. Allow the rate of outdoor air to be reduced to 0.15 cfm per square foot of conditioned floor area if the demand control ventilation device indicates that the space conditions are acceptable; and
- B. Be approved by the commission; and
- C. If the device is a carbon dioxide sensor, limit the carbon dioxide level to no more than 800 ppm while the space is occupied; and

**NOTE:** Control to 800 ppm is not required when the ventilation rate is equal to or greater than that required by Section 121 (b) 2.

- D. Include a sensor for the device located (1) in the space; or (2) in a return-air stream from the space with no less than one sensor for every 25,000 square feet of habitable space, or no more space than is recommended by the manufacturer, whichever is less.

**(d) Ducting for Zonal Heating and Cooling Units.** Where a return plenum is used to distribute outdoor air to a zonal heating or cooling unit which then supplies the air to a space in order to meet the requirements of Section 121 (b) 2, the outdoor air shall be ducted to discharge either:

## SUBCHAPTER 4

### NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES—MANDATORY REQUIREMENTS FOR LIGHTING SYSTEMS AND EQUIPMENT

#### SECTION 130 — LIGHTING SYSTEMS AND EQUIPMENT—GENERAL

(a) Except as provided in Subsection (b), the design and installation of all lighting systems and equipment in nonresidential, high-rise residential, and hotel/motel buildings subject to Title 24, Part 6, shall comply with the applicable provisions of Sections 131 through 139.

(b) The design and installation of all lighting systems and equipment in high-rise residential living quarters and in hotel/motel guest rooms shall comply with the following:

1. Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. A luminaire which is the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by the most accessible switch(es) in the kitchen.

Additional luminaires to be used only for specific decorative effects need not meet this requirement.

2. Each room containing a water closet shall have at least one luminaire with lamps with an efficacy of not less than 40 lumens per watt. If there is more than one luminaire in the room, the high efficacy luminaire shall be switched at an entrance to the room. The efficacy requirement may be met by installing the luminaire meeting this requirement in an adjacent room that has complementary plumbing fixtures.

3. Luminaires installed to meet the 40 lumens per watt requirements of Subsections 1 or 2 shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.

4. All incandescent lighting fixtures recessed into insulated ceilings shall be approved for zero-clearance insulation cover (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials.

**EXCEPTION to Section 130 (b):** Up to 10 percent of the guest rooms in a hotel/motel need not comply.

(c) **Exterior Building Lighting.** All permanently installed exterior luminaires attached to or powered by the electrical service in buildings that contain conditioned space(s), and employing lamps rated over 100 watts, shall either have a source efficacy, determined by dividing the rated initial lamp lumens by the rated lamp watts, of at least 60 lumens per watt; or be controlled by a motion sensor.

**EXCEPTION 1 to Section 130 (c):** Lighting required by a health or life-safety statute, ordinance, or regulation, including but not limited to, emergency lighting.

**EXCEPTION 2 to Section 130 (c):** Lighting that is integral to advertising signage.

**EXCEPTION 3 to Section 130 (c):** Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the 1998 *California Electrical Code*.

**EXCEPTION 4 to Section 130 (c):** Searchlights and lighting for use in theme parks.

**EXCEPTION 5 to Section 130 (c):** Outdoor theatrical equipment, provided it is for temporary or periodic use and is not for continuous use.

(d) Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following criteria:

1. The wattage of incandescent or tungsten-halogen luminaires with medium screw base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaire.

2. The wattage of luminaires with permanently installed or remotely installed ballasts shall be the operating input wattage of the specified lamp/ballast combination based on values from manufacturer's catalogs or values from independent testing lab reports.

3. The wattage of line-voltage lighting track and plug-in busway which allow the addition or relocation of luminaires without altering the wiring of the system shall be the volt-ampere rating of an integral current limiter controlling the luminaires, or the higher of the specified wattage of the luminaires included in the system, or 45 watts per linear foot.

4. The wattage of low-voltage lighting track, cable conductor, rail conductor, and other low-voltage flexible lighting systems, which allow the addition or relocation of luminaires without altering the wiring of the system, shall be the specified wattage of the transformer supplying the system.

5. The wattage of all other miscellaneous lighting equipment shall be the specified wattage of the lighting equipment.

#### SECTION 131 — LIGHTING CONTROLS THAT MUST BE INSTALLED

##### (a) Area Controls.

1. Each area enclosed by ceiling-height partitions shall have an independent switching or control device. This switching or control device shall be:

- A. Readily accessible; and
- B. Located so that a person using the device can see the lights or area controlled by that switch, or so that the area being lit is annunciated; and
- C. Manually operated, or automatically controlled by an occupant-sensing device that meets the requirements of Section 119 (d).

2. Other devices may be installed in conjunction with the switching or control device provided that they:

- A. Permit the switching or control device to override the action of all other devices; and
- B. Reset the mode of any automatic system to normal operation without further action.

**EXCEPTION 1 to Section 131 (a):** Up to one-half watt per square foot of lighting in any area within a building that must be continuously illuminated for reasons of building security or emergency egress, if:

- A. The area is designated a security or emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103 (a) (2) of Title 24, Part 1; and

- B. The area is controlled by switches accessible only to authorized personnel.

**EXCEPTION 2 to Section 131 (a):** Public areas with switches that are accessible only to authorized personnel.

(b) **Controls to Reduce Lighting.** The general lighting of any enclosed space 100 square feet or larger in which the connected lighting load exceeds 0.8 watt per square foot for the space as a whole, and that has more than one light source (luminaire), shall be controlled so that the load for the lights may be reduced by at least one half while maintaining a reasonably uniform level of illuminance throughout the area. A reasonably uniform reduction of illuminance shall be achieved by:

1. Controlling all lamps or luminaires with dimmers; or
2. Dual switching of alternate rows of luminaires, alternate luminaires, or alternate lamps; or
3. Switching the middle lamps of three lamp luminaires independently of the outer lamps; or
4. Switching each luminaire or each lamp.

**EXCEPTION to Section 131 (b):** Lights in corridors.

(c) **Daylit Areas.** Daylit areas in any enclosed space greater than 250 square feet shall meet the requirements of Items 1 and 2 below.

1. Such areas shall have at least one control that:
  - A. Controls only luminaires in the daylit area; and
  - B. Controls at least 50 percent of the lamps or luminaires in the daylit area, in a manner described in Section 131 (b) 1 through 4, independent of all other lamps or luminaires in the enclosed space. The other luminaires in the enclosed space may be controlled in any manner allowed by Section 131 (b) 1 through 4.
2. Such areas shall have controls that control the luminaires in each vertically daylit area separately from the luminaires in each horizontally daylit area.

**EXCEPTION 1 to Section 131 (c):** Daylit areas where the effective aperture of glazing is equal to or less than 0.1 for vertical glazing and 0.01 for horizontal glazing.

**EXCEPTION 2 to Section 131 (c):** Daylit areas where existing adjacent structures or natural objects obstruct daylight to the extent that effective use of daylighting is not feasible.

**(d) Shut-off Controls.**

1. For every floor, all interior lighting systems shall be equipped with a separate automatic control to shut off the lighting. This automatic control shall meet the requirements of Section 119 and may be an occupancy sensor, automatic time switch, or other device capable of automatically shutting off the lighting.

**EXCEPTION 1 to Section 131 (d) 1:** Where the system is serving an area that must be continuously lit, or lit in a manner requiring manual operation of the lighting.

**EXCEPTION 2 to Section 131 (d) 1:** Lighting in corridors, guest rooms, and lodging quarters of high-rise residential buildings and hotel/motels.

**EXCEPTION 3 to Section 131 (d) 1:** Up to  $1/2$  watt per square foot of lighting in any area within a building that must be continuously illuminated for reasons of building security or emergency egress, if:

- A. The area is designated a security or emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103 (a) 2A of Title 24, Part 1; and
  - B. The area is controlled by switches accessible only to authorized personnel.
2. If an automatic time switch control device is installed to comply with Section 131 (d) 1, it shall incorporate an override switching device that:
- A. Is readily accessible; and

- B. Is located so that a person using the device can see the lights or the area controlled by that switch, or so that the area being lit is annunciated; and
- C. Is manually operated; and
- D. Allows the lighting to remain on for no more than two hours when an override is initiated; and
- E. Controls an area not exceeding 5,000 square feet.

**EXCEPTION to Section 131 (d) 2 D:** In malls and arcades, auditoriums, single tenant retail spaces, industrial facilities, and arenas where captive-key override is utilized, override time may exceed 2 hours.

**EXCEPTION to Section 131 (d) 2 E:** In malls and arcades, auditoriums, single tenant retail spaces, industrial facilities, and arenas, the area controlled may not exceed 20,000 square feet.

3. If an automatic time switch control device is installed to comply with Section 131 (d) 1, it shall incorporate an automatic holiday "shut-off" feature that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.

**EXCEPTION to Section 131 (d) 3:** Retail stores and associated malls, restaurants, grocery stores, churches and theaters.

(e) **Display Lighting.** Display lighting shall be separately switched on circuits that are 20 amps or less.

(f) **Exterior Lighting.** All permanently installed exterior lighting attached to or powered by the electrical service in buildings that contain conditioned space(s) shall be controlled by a directional photocell or astronomical time switch that automatically turns off the exterior lighting when daylight is available.

**EXCEPTION to Section 131 (f):** Lighting in parking garages, tunnels and large covered areas that require illumination during daylight hours.

## SECTION 132 — REQUIREMENTS FOR LIGHTING CIRCUITING

The following shall be tandem wired and shall not use single lamp ballasts:

(a) Pairs of one-lamp or three-lamp recessed fluorescent luminaires that are (1) on the same switch control, (2) in the same area, and (3) within 10 feet of each other in accessible ceiling spaces; and

(b) Continuous mounted pendant and continuous surface-mounted luminaires.

**EXCEPTION 1 to Section 132:** Fluorescent lighting luminaires that use electronic high frequency ballasts.

**EXCEPTION 2 to Section 132:** Single lamp ballasts may be used for odd lamp quantities or in conjunction with emergency battery-ballast units in even-numbered lamp luminaires.

**EXCEPTION to Sections 131 and 132:** Exit signs and illumination subject to Section 1012 or 1013 of the California Building Code, and lighting whose switching is regulated by Article 700 of the California Electrical Code (Title 24, Part 3).

**SECTION 133 — Reserved.**

**SECTION 134 — Reserved.**

**SECTION 135 — Reserved.**

**SECTION 136 — Reserved.**

**SECTION 137 — Reserved.**

**SECTION 138 — Reserved.**

**SECTION 139 — Reserved.**

1. Within 5 feet of the unit; or
2. Within 15 feet of the unit, substantially toward the unit, and at a velocity not less than 500 feet per minute.

(e) **Design and Control Requirements for Quantities of Outdoor Air.** All mechanical ventilation and space-conditioning systems shall be designed with and have installed ductwork, dampers and controls to allow outside air rates to be operated at the larger of (1) the minimum levels specified in Section 121 (b) 2; or (2) the rate required for make-up of exhaust systems that are required for a process, for control of odors, or for the removal of contaminants within the space.

(f) **Completion and Balancing.** Before an occupancy permit is granted for a new building or space, or a new space-conditioning or ventilating system serving a building or space is operated for normal use, all ventilation systems serving the building or space shall be documented in accordance with Title 8, Section 5142 (b) of the California Safety Code (1987) to be providing the minimum ventilation rate specified in Section 121 (b) 2, as determined using one of the following procedures:

1. **Balancing.** The system shall be balanced in accordance with the National Environmental Balancing Bureau (NEBB) Procedural Standards (1983) or Associated Air Balance Council (AABC) National Standards (1989); or
2. **Outside air certification.** The system shall provide the minimum outside air as shown on the mechanical drawings, and shall be measured by the installing licensed C-20 mechanical contractor and certified by (1) the design mechanical engineer, (2) the installing licensed C-20 mechanical contractor, or (3) the person with overall responsibility for the design of the ventilation system; or
3. **Outside air measurement.** The system shall be equipped with a calibrated local or remote device capable of measuring the quantity of outside air on a continuous basis and displaying that quantity on a readily accessible display device; or
4. Another method approved by the commission.

## SECTION 122 — REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

Space-conditioning systems shall be installed with controls that comply with the applicable requirements of Subsections (a) through (g).

(a) **Thermostatic Controls for Each Zone.** The supply of heating and cooling energy to each space-conditioning zone or dwelling unit shall be controlled by an individual thermostatic control that responds to temperature within the zone and that meets the applicable requirements of Subsection (b).

**EXCEPTION to Section 122 (a):** An independent perimeter heating or cooling system may serve more than one zone without individual thermostatic controls if:

- A. All zones are also served by an interior cooling system;
- B. The perimeter system is designed solely to offset envelope heat losses or gains;
- C. The perimeter system has at least one thermostatic control for each building orientation of 50 feet or more; and
- D. The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

(b) **Criteria for Zonal Thermostatic Controls.** The individual thermostatic controls required by Subsection (a) shall meet the following requirements as applicable:

1. Where used to control comfort heating, the thermostatic controls shall be capable of being set, locally or remotely, by adjustment or selection of sensors, down to 55°F or lower.

2. Where used to control comfort cooling, the thermostatic controls shall be capable of being set, locally or remotely, by adjustment or selection of sensors, up to 85°F or higher.

3. Where used to control both comfort heating and comfort cooling, the thermostatic controls shall meet Items 1 and 2 and shall be capable of providing a temperature range or dead band of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

**EXCEPTION 1 to Section 122 (b) 3:** Systems with thermostats that require manual changeover between heating and cooling modes.

**EXCEPTION 2 to Section 122 (b) 1, 2 and 3:** Systems serving zones that must have constant temperatures to prevent degradation of materials, a process, or plants or animals.

(c) **Hotel/Motel Guest Room and High-rise Residential Dwelling Unit Thermostats.** Hotel/motel guest room thermostats shall have:

1. Numeric temperature setpoints in °F; and
2. Setpoint stops accessible only to authorized personnel, to restrict overheating and overcooling.

High-rise residential dwelling unit thermostats shall meet the control requirements of Section 150 (i).

(d) **Heat Pump Controls.** All heat pumps with supplementary electric resistance heaters shall be installed with controls that comply with Section 112 (b).

(e) **Shut-off and Reset Controls for Space-conditioning Systems.** Each space-conditioning system shall be installed with controls that comply with Items 1 and 2 below:

1. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:
  - A. An automatic time switch control device complying with Section 119 (c), with an accessible manual override that allows operation of the system for up to four hours; or
  - B. An occupancy sensor; or
  - C. A four-hour timer that can be manually operated.
2. The control shall automatically restart and temporarily operate the system as required to maintain:

- A. A setback heating thermostat setpoint if the system provides mechanical heating; and
- B. A setup cooling thermostat setpoint if the system provides mechanical cooling.

**EXCEPTION 1 to Section 122 (e):** Where it can be demonstrated to the satisfaction of the enforcing agency that the system serves an area that must operate continuously.

**EXCEPTION 2 to Section 122 (e):** Where it can be demonstrated to the satisfaction of the enforcing agency that shutdown, setback, and setup will not result in a decrease in overall building source energy use.

**EXCEPTION 3 to Section 122 (e):** Systems with full load demands of 2 kw or less, if they have a readily accessible manual shut-off switch.

**EXCEPTION 4 to Section 122 (e):** Systems serving hotel/motel guest rooms, if they have a readily accessible manual shut-off switch.

**EXCEPTION to Section 122 (e) 1:** Mechanical systems serving retail stores and associated malls, restaurants, grocery stores, churches and theaters equipped with 7-day programmable timers.

**EXCEPTION to Section 122 (e) 2A:** Thermostat setback controls are not required in areas where the Winter Median of Extremes outdoor air temperature determined in accordance with Section 144 (b) 4 is greater than 32°F.

**EXCEPTION to Section 122 (e) 2B:** Thermostat setup controls are not required in areas where the Summer Design Dry Bulb 0.5% temperature determined in accordance with Section 144 (b) 4 is less than 100°F.

(f) **Dampers for Air Supply and Exhaust Equipment.** Outdoor air supply and exhaust equipment shall be installed with dampers that automatically close upon fan shutdown.

**EXCEPTION 1 to Section 122 (f):** Where it can be demonstrated to the satisfaction of the enforcing agency that the equipment serves an area that must operate continuously.

**EXCEPTION 2 to Section 122 (f):** Gravity and other nonelectrical equipment that has readily accessible manual damper controls.

**EXCEPTION 3 to Section 122 (f):** At combustion air intakes and shaft vents.

**EXCEPTION 4 to Section 122 (f):** Where prohibited by other provisions of law.

(g) **Isolation Area Devices.** Each space-conditioning system serving multiple zones with a combined conditioned floor area of more than 25,000 square feet shall be designed, installed and controlled to serve isolation areas.

1. Each zone, or any combination of zones not exceeding 25,000 square feet, shall be a separate isolation area.
2. Each isolation area shall be provided with isolation devices, such as valves or dampers, that allow the supply of heating or cooling to be set back or shut off independently of other isolation areas.
3. Each isolation area shall be controlled by a device meeting the requirements of Section 122 (e) 1.

**EXCEPTION to Section 122 (g):** A zone need not be isolated if it can be demonstrated to the satisfaction of the enforcement agency that the zone must be heated or cooled continuously.

## SECTION 123 — REQUIREMENTS FOR PIPE INSULATION

The piping for all space-conditioning and service water-heating systems with fluid temperatures listed in Table 1-G shall have the amount of insulation specified in Subsection (a) or (b). Insulation conductivity shall be determined in accordance with ASTM C 335-95 at the mean temperature listed in Table 1-G, and shall be rounded to the nearest  $1/100$  Btu-inch per hour per square foot per °F.

Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, including but not limited to, the following:

Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

Insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

**EXCEPTION 1 to Section 123:** Factory-installed piping within space-conditioning equipment certified under Section 111 or 112.

**EXCEPTION 2 to Section 123:** Piping that conveys fluids with a design operating temperature range between 60°F and 105°F.

**EXCEPTION 3 to Section 123:** Piping that serves process loads, gas piping, cold domestic water piping, condensate drains, roof drains, vents or waste piping.

**EXCEPTION 4 to Section 123:** Where the heat gain or heat loss to or from piping without insulation will not increase building source energy use.

(a) For insulation with a conductivity in the range shown in Table 1-G for the applicable fluid temperature range, the insulation shall have the applicable thickness shown in Table 1-G.

(b) For insulation with a conductivity outside the range shown in Table 1-G for the applicable fluid temperature range, the insulation shall have a minimum thickness as calculated with Equation (1-A):

### EQUATION (1-A)—INSULATION THICKNESS

$$T = PR [(1 + t/PR)^{K/k} - 1] \quad (1-A)$$

#### WHERE:

$T$  = minimum insulation thickness for material with conductivity  $K$ , inches.

$PR$  = pipe actual outside radius, inches.

$t$  = insulation thickness from Table 1-G, inches.

$K$  = conductivity of alternate material at the mean rating temperature indicated in Table 1-G for the applicable fluid temperature range, in Btu-inch per hour per square foot per °F.

$k$  = The lower value of the conductivity range listed in Table 1-G for the applicable fluid temperature range, Btu-inch per hour per square foot per °F.

## SECTION 124 — REQUIREMENTS FOR AIR DISTRIBUTION SYSTEM DUCTS AND PLENUMS

(a) **CMC Compliance.** All air distribution system ducts and plenums, including but not limited to building cavities, mechanical closets, air-handler boxes and support platforms used as ducts or plenums, shall be installed, sealed and insulated to meet the requirements of the 1998 CMC Sections 601, 603, 604 and Standard 6-3<sup>2</sup>, incorporated herein by reference. Portions conveying conditioned air shall either be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 604<sup>3</sup>) or be enclosed entirely in conditioned space. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than  $1/4$  inch, the combination of mastic and either mesh or tape shall be used.

#### (b) Duct and Plenum Materials.

##### 1. Factory-fabricated duct systems.

- A. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices, and be UL labeled.
- B. All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181.
- C. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 or UL 181B.
- D. Joints and seams of duct systems and their components shall not be sealed with cloth-back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

<sup>2</sup>On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct installation, sealing and insulation shall comply with Sections 601, 602, 604, 605 and Standard 6-5 of the 2000 CMC.

<sup>3</sup>On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct insulation shall comply with Section 605 of the 2000 CMC.

**2. Field-fabricated duct systems.**

- A. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A or UL 181B.
- B. **Mastic sealants and mesh.**
- Sealants shall comply with UL 181, UL 181A, or UL 181B, and be nontoxic and water resistant.
  - Sealants for interior applications shall pass ASTM tests C 731 (extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.
  - Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.
  - Sealants and meshes shall be rated for exterior use.
- C. **Pressure-sensitive tape.** Pressure-sensitive tapes shall comply with UL 181, UL 181A or UL 181B.
- D. Joints and seams of duct systems and their components shall not be sealed with cloth-back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.
- E. **Drawbands used with flexible duct.**
- Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
  - Drawbands shall have a minimum tensile strength rating of 150 pounds.
  - Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.
- F. **Aerosol-sealant closures.**
- Aerosol sealants shall meet the applicable requirements of UL 181, 181A or 181B and be applied according to manufacturer specifications.
  - Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

(c) All duct insulation product R-values shall be based on insulation only (excluding air films, vapor barriers, or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C 518-85 or ASTM C 177-85, incorporated herein by reference, and certified pursuant to Section 118.

(d) The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

1. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

2. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

(e) Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor barriers, or other duct components), based on the tests in Section 124 (c) and the installed thickness determined by Section 124 (d) 3.

(f) **Protection of Insulation.** Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, but not limited to the following:

Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

**SECTION 125 — Reserved.**

**SECTION 126 — Reserved.**

**SECTION 127 — Reserved.**

**SECTION 128 — Reserved.**

**SECTION 129 — Reserved.**

TABLE 1-F—MINIMUM VENTILATION RATES

TYPE OF USE	CFM PER SQUARE FOOT OF CONDITIONED FLOOR AREA
Auto repair workshops	1.50
Barber shops	0.40
Bars, cocktail lounges and casinos	1.50
Beauty shops	0.40
Coin-operated dry cleaning	0.30
Commercial dry cleaning	0.45
High-rise residential	Per UBC Section 1203
Hotel guest rooms (less than 500 sq. ft.)	30 cfm/guest room
Hotel guest rooms (500 sq. ft. or greater)	0.15
Retail stores	0.20
Smoking lounges	1.50
All others	0.15

TABLE 1-G—PIPE INSULATION THICKNESS

FLUID TEMPERATURE RANGE, (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot per °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)					
			Runouts up to 2	1 and less	1.25-2	2.50-4	5-6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)					
Space heating systems (steam, steam condensate and hot water)								
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Service water-heating systems (recirculating sections, all piping in electric trace tape systems, and the first 8 feet of piping from the storage tank for nonrecirculating systems)								
Above 105	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)								
40-60	0.23-0.27	75	0.5	0.5	0.5	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5



## SUBCHAPTER 5

# NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES—PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR ACHIEVING ENERGY EFFICIENCY

## SECTION 140 — CHOICE OF PERFORMANCE AND PRESCRIPTIVE APPROACHES

The envelope and the space-conditioning, lighting and service water-heating systems of all nonresidential, high-rise residential, and hotel/motel buildings subject to Title 24, Part 6, shall be designed, constructed and installed either:

(a) **Performance Approach**—to use no more source energy from depletable sources than the energy budget, calculated according to Section 141; or

(b) **Prescriptive Approach**—in accordance with all the applicable requirements of Sections 142 through 146.

## SECTION 141 — PERFORMANCE APPROACH: ENERGY BUDGETS

In order to meet the energy budget, a proposed building's use of source energy calculated under Subsection (b) must be no greater than the energy budget calculated under Subsection (a).

(a) **Energy Budget.** The energy budget for a proposed building is the sum of the space-conditioning, lighting and service water-heating budgets in Subdivisions 1, 2 and 3 of this subsection, expressed in Btu per square foot of conditioned floor area per year.

1. **Space-conditioning budget.** The space-conditioning budget is the source energy used for space conditioning in a standard building in the climate zone in which the proposed building is located, calculated with a method approved by the commission (expressed in Btu per square foot of conditioned floor area per year), and assuming that:

- A. The standard building has space heating, space cooling and ventilation systems that meet, but do not exceed, the minimum efficiency requirements of Sections 111 and 112, and the requirements of Section 144; and
- B. The performance of the roof/ceiling, walls, floors and soffits, windows, and skylights is equal to an applicable value using the same assembly type from Table 1-I or 1-J; and
- C. The zoning, the orientation of each building feature, and the gross envelope areas of the standard building are the same as in the proposed building; and
- D. The window area of the standard building is the greater of (1) or (2): (1) the window area of the proposed building, excluding the window area in demising walls, or 40 percent of the gross exterior wall area of the standard building, whichever is less; or (2) 6 feet times the display perimeter; and
- E. The skylight area of the standard building is the same as in the proposed building, or is 5 percent of the gross exterior roof/ceiling area of the standard building, whichever is less.

2. **Lighting budget.** The lighting budget is the source energy used for lighting in a standard building calculated with a method approved by the commission (expressed in Btu per square foot of conditioned floor area per year), and assuming that:

- A. The lighting power density of the standard building, for areas where no lighting plans or specifications are submitted for permit and the occupancy of the building is known, is the maximum allowed lighting power density calculated according to Section 146 (b) 1; and
- B. The lighting power density of the standard building, for areas where no lighting plans or specifications are submitted for permit, and the occupancy of the building is not known, is 1.2 watts per square foot; and
- C. The lighting power density of the standard building, for areas where lighting plans and specifications are being submitted for permit, is the maximum allowed lighting power density calculated according to Section 146 (b) 1, 2 or 3.

3. **Service water-heating budget.** The service water-heating budget is the source energy used for service water heating in a standard building in the climate zone in which the proposed building is located, calculated with a method approved by the commission (expressed in Btu per square foot of conditioned floor area per year), and assuming that the standard building has a service water-heating system that meets, but does not exceed, the applicable requirements of Sections 111, 113 and 123.

(b) **Source Energy Use of Proposed Building.** The source energy use of a proposed building is the sum of the space-conditioning, lighting and service water-heating source energy use calculated in Subdivisions 1, 2 and 3 of this subsection, using the same ACM used to calculate the budget under Subsection (a), and expressed in Btu per square foot of conditioned floor area per year. If any feature of the proposed building, including, but not limited to, the envelope or the space-conditioning, lighting or service water-heating system, is not included in the building permit application, the energy performance of the feature shall be assumed to be that of the corresponding feature calculated in Subsection (a).

1. **Space-conditioning source energy use.** The space-conditioning source energy use shall be calculated by:

- A. Using a method approved by the commission; and
- B. Using the proposed building's space heating, space cooling, lighting, and ventilation systems, roof and ceiling, walls, floors and soffits, opaque envelope areas, windows, skylights, zoning, and orientation, as shown on the plans and specifications submitted in the building permit application under Section 10-103 of Title 24, Part 1.

2. **Lighting source energy use.** The lighting source energy use shall be calculated using a method approved by the commission, and using the actual lighting power density calculated under Section 146 (a), including reduction of wattage through controls.

3. **Service water-heating source energy use.** The service water-heating source energy use shall be calculated using a method approved by the commission, and using the proposed building's actual service water-heating system.

(c) **Calculation of Budget and Energy Use.** When calculating the energy budget under Subsection (a) and the source energy use under Subsection (b), all of the following rules shall apply:

1. **Methodology.** The methodology, computer programs, inputs and assumptions approved by the commission shall be used.

2. **Energy included.** All energy from depletable sources used for space conditioning, lighting and service water heating shall be included.

3. **Energy excluded.** The following energy shall be excluded:

- A. Process loads; and
- B. Loads of redundant or backup equipment, if the plans submitted under Section 10-103 of Title 24, Part 1, show controls that will allow the redundant or backup equipment to operate only when the primary equipment is not operating, and if such controls are installed; and
- C. Recovered energy; and
- D. Additional energy use caused solely by outside air filtration and treatment for the reduction and treatment of unusual outdoor contaminants with final pressure drops more than 1-inch water column. Only the energy accounted for by the amount of the pressure drop that is over 1 inch may be excluded.

4. **U-factors.** U-factors shall be calculated as follows:

- A. **All building components.** The U-factor of all building components shall be calculated to three decimal places; the calculations shall assume still inside air and a 15 miles per hour outside air velocity, or other assumptions approved by the commission.
- B. **Wood-framed assemblies.** U-factors for wood-framed assemblies shall be calculated using the parallel path method listed in ASHRAE Handbook, 1993, Fundamentals Volume, Chapter 22, with framing factors approved by the commission.
- C. **Metal-framed assemblies.** U-factors for metal-framed assemblies shall be calculated using the zone method listed in ASHRAE Handbook, 1993, Fundamentals Volume, Chapter 22, or a method approved by the commission.
- D. **Fenestration.** U-factors for fenestration shall be determined as follows:
  - i. For site-assembled fenestration products, U-factors shall include the effects of framing and shall be determined using NFRC procedures or default values as set forth in Section 116; or
  - ii. For manufactured windows, U-factors shall be as certified under Section 116; or
  - iii. Using a method approved by the commission.
- E. **Masonry assemblies.** U-factors for masonry assemblies shall be calculated using the transverse isothermal planes method listed in ASHRAE Handbook, 1993, Fundamentals Volume, Chapter 22, or a method approved by the commission.
- F. **Other.** U-factors for components not listed in this subsection shall be calculated using a method approved by the commission.

5. **Solar heat gain coefficients.** Solar heat gain coefficients shall be determined using National Fenestration Rating Council's NFRC 200 (1995), or NFRC 100-SB, as set forth in Section 116, and shall not be adjusted for the effects of interior or exterior shading devices.

6. **Visible light transmittance.** Visible light transmittance shall be determined using the values listed in ASHRAE Handbook, 1993, Fundamentals Volume, Chapter 27, or manufacturers' literature, and shall be adjusted for the effects of framing and interior or exterior shading devices.

## SECTION 142 — PRESCRIPTIVE APPROACH

In order to comply with the prescriptive approach under this section, a building shall be designed with and shall have constructed and installed:

- (a) A building envelope that complies with Section 143 (a) or (b);
- (b) A space-conditioning system that complies with Section 144;
- (c) A service water-heating system that complies with Section 145; and
- (d) A lighting system that complies with Section 146.

## SECTION 143 — PRESCRIPTIVE REQUIREMENTS FOR BUILDING ENVELOPES

A building complies with this section by being designed with and having constructed and installed either (1) envelope components that comply with each of the requirements in Subsection (a) for each individual component, or (2) an envelope that complies with the overall requirements in Subsection (b). When making calculations under Subsection (a) or (b), all of the rules listed in Section 141 (c) 1, 4 and 5 shall apply.

### (a) Envelope Component Approach.

1. **Exterior roofs and ceilings.** Exterior roofs and ceilings shall have either an installed insulation R-value no less than, or an overall assembly U-factor no greater than, the applicable value in Table 1-H or 1-I.

2. **Exterior walls.** Exterior walls shall have either an installed insulation R-value no less than, or an overall assembly U-factor no greater than, the applicable value in Table 1-H or 1-I.

3. **Demising walls.** The opaque portions of framed demising walls in nonresidential buildings shall have insulation with an installed insulation R-value no less than R-11 between framing members.

4. **External floors and soffits.** External floors and soffits shall have either an installed insulation R-value no less than, or an overall assembly U-factor no greater than, the applicable value in Table 1-H or 1-I.

### 5. Windows. Windows shall:

- A. Have an area no greater than 40 percent of the gross exterior wall area, or 6 feet times the display perimeter, whichever is greater; and

**EXCEPTION to Section 143 (a) 5 A:** Window area in demising walls is not counted as part of the window area for this requirement. Demising wall area is not counted as part of the gross exterior wall area or display perimeter.

- B. Have a U-factor no greater than the applicable value in Table 1-H or 1-I; and
- C. Have a relative solar heat gain, excluding the effects of interior shading, no greater than the applicable value in Table 1-H or 1-I. The relative solar heat gain of windows is:
  - i. The solar heat gain coefficient of the windows; or
  - ii. Relative solar heat gain as calculated by Equation (1-B), if an overhang extends beyond both sides of

the window jamb a distance equal to the overhang projection.

**EXCEPTION to Section 143 (a) 5 C:** The applicable “north” value for relative solar heat gain in Table 1-H or 1-I or 0.56, whichever is greater, shall be used for windows:

A. That are in the first story of exterior walls that form a display perimeter; and

B. For which codes restrict the use of overhangs to shade the windows.

#### EQUATION (1-B)—RELATIVE SOLAR HEAT GAIN EQUATION

$$RSHG = SHGC_{win} \times [1 + aH/V + b(H/V)^2] \quad (1-B)$$

#### WHERE:

$RSHG$  = relative solar heat gain.

$SHGC_{win}$  = solar heat gain coefficient of the window.

$H$  = horizontal projection of the overhang from the surface of the window in feet, but no greater than  $V$ .

$V$  = vertical distance from the window sill to the bottom of the overhang, in feet.

$a$  = -0.41 for north-facing windows, -1.22 for south-facing windows, and -0.92 for east- and west-facing windows.

$b$  = 0.20 for north-facing windows, 0.66 for south-facing windows, and 0.35 for east- and west-facing windows.

#### 6. Skylights. Skylights shall:

A. Have an area no greater than 5 percent of the gross exterior roof area; and

**EXCEPTION to Section 143 (a) 6 A:** Atria over 55 feet high shall have a skylight area no greater than 10 percent of the gross exterior roof area.

B. Have a U-factor no greater than the applicable value in Table 1-H or 1-I; and

C. Have a solar heat gain coefficient no greater than the applicable value in Table 1-H or 1-I.

7. **Exterior doors.** Exterior doors have no R-value, U-factor, or area requirements.

#### (b) Overall Envelope Approach.

1. **Overall heat loss.** The overall heat loss (HL) of the overall envelope of the proposed building,  $HL_{prop}$  as calculated with Equation (1-D), shall be no greater than the overall heat loss of a standard building,  $HL_{std}$  as calculated with Equation (1-C). In making the calculations, it shall be assumed that the orientation and area of each envelope component is the same as in the proposed building.

#### EQUATION (1-C)—STANDARD BUILDING HEAT LOSS

$$HL_{std} = \sum_{i=1}^{nW} (A_{Wi} \times U_{Wi_{std}}) + \sum_{i=1}^{nF} (A_{Fi} \times U_{Fi_{std}}) + \sum_{i=1}^{nR} (A_{Ri} \times U_{Ri_{std}}) + \sum_{i=1}^{nG} (A_{Gi} \times U_{Gi_{std}}) + \sum_{i=1}^{nS} (A_{Si} \times U_{Si_{std}}) \quad (1-C)$$

#### WHERE:

$HL_{std}$  = overall heat loss of the standard building (in Btu/h-°F).

$i$  = each wall type and orientation, floor/soffit type, roof/ceiling type, window (glazing) type and orientation, or skylight type for the standard building.

$nW, nR,$

$nG, nF,$

$nS$  = number of components of the applicable envelope feature.

$A_{Wi}$  = exterior wall area on the north, east, south, and west orientations of the proposed building (in ft<sup>2</sup>) including the window area on that orientation of the proposed building, minus  $A_{Gi}$ . The standard building has as many walls in each orientation as there are HC categories in that orientation of the proposed building.

$A_{Fi}$  = exterior floor/soffit area of the proposed building (in ft<sup>2</sup>). The standard building has as many floors/soffits as there are HC categories in the floors/soffits of the proposed building.

$A_{Ri}$  = exterior roof/ceiling area of the proposed building (in ft<sup>2</sup>) plus the skylight area of the proposed building, less  $A_{Si}$ .

$A_{Gi}$  = Window (glazing) area of each type on the north, east, south, and west orientations of the standard building (in ft<sup>2</sup>). If the total window wall ratio of the proposed building is more than 40 percent, the total window area is the greater of (a) 40 percent of the gross exterior wall area, or (b) 6 feet times the display perimeter. The window area of each type and on each orientation of the standard design shall be decreased in proportion to the area in the proposed design according to one of the following formulas as applicable:

$$(a) A_{Gi-adj} = (A_{Gi-prop}/A_{Gtotal-prop}) \times 0.40 \times A_{Wtotal-prop}$$

$$(b) A_{Gi-adj} = (A_{Gi-prop}/A_{Gtotal-prop}) \times (6 \times \text{Display Perimeter})$$

If the total window area of the proposed building is less than 10 percent of the gross exterior wall area, the window area of each type and on each orientation of the standard design shall be increased in proportion to the area in the proposed design according to the following formula:

$$A_{Gi-adj} = (A_{Gi-prop}/A_{Gtotal-prop}) \times 0.10 \times A_{Wtotal-prop}$$

#### WHERE:

$A_{Gi-adj}$  = Adjusted window area of each type on the north, east, south, and west orientations (in ft<sup>2</sup>).

$A_{Gi-prop}$  = Actual proposed window area of each type in the respective orientation (in ft<sup>2</sup>).

$A_{Gtotal-prop}$  = Total actual proposed window area of the proposed building (in ft<sup>2</sup>).

$A_{Wtotal-prop}$  = Total actual proposed gross exterior wall area of the proposed building (in ft<sup>2</sup>).

$A_{Si}$  = skylight area of the standard building for each skylight type (in ft<sup>2</sup>). The total skylight area in the standard building is equal to the total skylight area of the proposed building or 5 percent of the gross exterior roof area (or, for atria over 55 feet high, 10 percent of the gross exterior roof area), whichever is less. If the total skylight area of the proposed building is more than 5 percent of the gross exterior roof area or more than 10 percent of the gross exterior roof area for atria over 55 feet high, the skylight area of each type of the standard building shall be decreased in proportion to the area in the proposed design according to the following formula:

$A_{Si-adj} = (A_{Si-prop}/A_{Stotal-prop}) \times 0.10 \times A_{Rtotal-prop}$   
for atria over 55 feet high, and

$A_{Si-adj} = (A_{Si-prop}/A_{Stotal-prop}) \times 0.05 \times A_{Rtotal-prop}$   
for others, where:

$A_{Si-adj}$  = Adjusted skylight area of each type (in ft<sup>2</sup>).

$A_{Si-prop}$  = Actual proposed skylight area of each type (in ft<sup>2</sup>).

$A_{Stotal-prop}$  = Total actual proposed skylight area of the proposed building (in ft<sup>2</sup>).

$A_{Rtotal-prop}$  = Total actual proposed gross exterior roof area of the proposed building (in ft<sup>2</sup>).

$U_{Wistd}$  = the applicable wall U-value for the corresponding  $A_{Wi}$  from Table 1-H or 1-I.

$U_{Fistd}$  = the applicable floor/soffit U-value for the corresponding  $A_{Fi}$  from Table 1-H or 1-I.

$U_{Ristd}$  = the applicable roof/ceiling U-value for the corresponding  $A_{Ri}$  from Table 1-H or 1-I.

$U_{Gistd}$  = the applicable window U-value for the corresponding  $A_{Gi}$  from Table 1-H or 1-I.

$U_{Sistd}$  = the applicable skylight U-value for the corresponding  $A_{Si}$  from Table 1-H or 1-I.

#### EQUATION (1-D)—PROPOSED BUILDING HEAT LOSS

$$HL_{prop} = \sum_{j=1}^{nW} (A_{Wj} \times U_{Wjprop}) + \sum_{j=1}^{nF} (A_{Fj} \times U_{Fjprop}) + \sum_{j=1}^{nR} (A_{Rj} \times U_{Rjprop}) + \sum_{j=1}^{nG} (A_{Gj} \times U_{Gjprop}) + \sum_{j=1}^{nS} (A_{Sj} \times U_{Sjprop})$$

#### WHERE:

$HL_{prop}$  = overall heat loss of the proposed building (in Btu/h-°F).

$j$  = each wall type and orientation, floor/soffit type, roof/ceiling type, window type and orientation, or skylight type for the proposed building.

$nW, nR,$   
 $nG, nF,$

$nS$  = as determined in Equation 1-C.

$A_{Wj}$  = exterior wall area on the north, east, south, and west orientations of the proposed building (in ft<sup>2</sup>). Each orientation has as many walls as there are HC categories.

$A_{Fj}$  = exterior floor/soffit area of the proposed building (in ft<sup>2</sup>). There are as many floors/soffits as there are HC categories.

$A_{Rj}$  = exterior roof/ceiling area of the proposed building (in ft<sup>2</sup>).

$A_{Gj}$  = window (glazing) area for each window type and orientation of the proposed building (in ft<sup>2</sup>).

$A_{Sj}$  = skylight area for each skylight type of the proposed building (in ft<sup>2</sup>).

$U_{Wjprop}$  = the wall U-factor for the corresponding  $A_{Wj}$ .

$U_{Fjprop}$  = the floor/soffit U-factor for the corresponding  $A_{Fj}$ .

$U_{Rjprop}$  = the roof/ceiling U-factor for the corresponding  $A_{Rj}$ .

$U_{Gjprop}$  = the window U-factor for the corresponding  $A_{Gj}$ .

$U_{Sjprop}$  = the skylight U-factor for the corresponding  $A_{Sj}$ .

2. **Overall heat gain.** The overall heat gain of the overall envelope of the proposed building,  $HG_{prop}$  as calculated with Equation (1-F), shall be no greater than the overall heat gain of the overall envelope of a standard building,  $HG_{std}$  as calculated with Equation (1-E). In making the calculations, it shall be assumed that the orientation and area of each envelope component of the standard building are the same as in the proposed building.

#### EQUATION (1-E)—STANDARD BUILDING HEAT GAIN

$$HG_{std} = \sum_{i=1}^{nW} (A_{Wi} \times U_{Wi_{std}} \times TF_i) + \sum_{i=1}^{nF} (A_{Fi} \times U_{Fi_{std}} \times TF_i) + \sum_{i=1}^{nR} (A_{Ri} \times U_{Ri_{std}} \times TF_i) + \sum_{i=1}^{nS} (WF_{Si} \times A_{Si} \times SHGC_{Si_{std}}) \times SF$$

$$HG_{std} = \sum_{i=1}^{nW} (A_{Wi} \times U_{Wi_{std}} \times TF_i) + \sum_{i=1}^{nF} (A_{Fi} \times U_{Fi_{std}} \times TF_i) + \sum_{i=1}^{nR} (A_{Ri} \times U_{Ri_{std}} \times TF_i) + \sum_{i=1}^{nG} (A_{Gi} \times U_{Gi_{std}} \times TF_i) + \sum_{i=1}^{nS} (A_{Si} \times U_{Si_{std}} \times TF_i) + \sum_{i=1}^{nG} (WF_{Gi} \times A_{Gi} \times RSHG_{Gi_{std}}) \times SF + \sum_{i=1}^{nS} (WF_{Si} \times A_{Si} \times SHGC_{Si_{std}}) \times SF + \sum_{i=1}^{nR} (WF_{Ri} \times A_{Ri} \times U_{Ri_{std}} \times \alpha_{Ristd}) \times SF$$

#### WHERE:

$HG_{std}$  = overall heat gain of the standard building (Btu/h).

$i$  = as determined in Equation 1-C.

$nW, nR,$   
 $nG, nF,$

$nS$  = as determined in Equation 1-C.

$A_{Wi}$  = as determined in Equation 1-C.

$A_{Fi}$  = as determined in Equation 1-C.

$A_{Ri}$  = as determined in Equation 1-C.

$A_{Gi}$  = as determined in Equation 1-C.

$A_{Si}$  = as determined in Equation 1-C.

$U_{Wistd}$  = as determined in Equation 1-C.

$U_{Fistd}$  = as determined in Equation 1-C.

$U_{Ristd}$  = as determined in Equation 1-C.

$U_{Gistd}$  = as determined in Equation 1-C.

$U_{Sistd}$  = as determined in Equation 1-C.

$RSHG_{Gistd}$  = the applicable relative solar heat gain for the corresponding  $A_{Gi}$ , from Table 1-H or 1-I (unitless).

$WF_{Gi}$  = the applicable weighting factor for glazing for each orientation of the standard building, from Table 1-K (unitless).

$WF_{Si}$  = the applicable weighting factor for skylight of the standard building, from Table 1-K (unitless).

$WF_{Ri}$  = the applicable weighting factor for roof of the standard building, from Table 1-K (unitless).

$\alpha_{Ristd}$  = A standard roof absorptivity of 0.70 for the corresponding  $A_{Ri}$ .

$SHGC_{Sistd}$  = the applicable solar heat gain coefficient for the corresponding  $A_{Si}$ , from Table 1-H or 1-I (unitless).

$SF$  = the solar factor from Table 1-J.

$TF_i$  = the temperature factor from Table 1-J.

#### EQUATION (1-F)—PROPOSED BUILDING HEAT GAIN

$$\begin{aligned}
 HG_{prop} &= \sum_{j=1}^{nW} (A_{Wj} \times U_{Wjprop} \times TF_j) + \\
 &\sum_{j=1}^{nF} (A_{Fj} \times U_{Fjprop} \times TF_j) + \sum_{j=1}^{nR} (A_{Rj} \times U_{Rjprop} \times TF_j) + \\
 &\sum_{j=1}^{nS} (WF_{Sj} \times A_{Sj} \times SHGC_{Sjprop}) \times SF \\
 \\
 HG_{prop} &= \sum_{j=1}^{nW} (A_{Wj} \times U_{Wjprop} \times TF_j) + \\
 &\sum_{j=1}^{nF} (A_{Fj} \times U_{Fjprop} \times TF_j) + \sum_{j=1}^{nR} (A_{Rj} \times U_{Rjprop} \times TF_j) + \\
 &\sum_{j=1}^{nG} (A_{Gj} \times U_{Gjprop} \times TF_j) + \sum_{j=1}^{nS} (A_{Sj} \times U_{Sjprop} \times TF_j) + \\
 &\sum_{j=1}^{nG} (WF_{Gj} \times A_{Gj} \times SHGC_{Gjprop} \times OHF_j) \times SF + \\
 &\sum_{j=1}^{nS} (WF_{Sj} \times A_{Sj} \times SHGC_{Sjprop}) \times SF + \\
 &\sum_{j=1}^{nR} (WF_{Rj} \times A_{Rj} \times U_{Rjprop} \times \alpha_{Rjstd}) \times SF
 \end{aligned}$$

#### WHERE:

$HG_{prop}$  = overall heat gain of the proposed building (Btu/h).

$j$  = as determined in Equation 1-D.

$nW, nR,$

$nG, nF,$

$nS$  = as determined in Equation 1-D.

$A_{Wj}$  = as determined in Equation 1-D.

$A_{Fj}$  = as determined in Equation 1-D.

$A_{Rj}$  = as determined in Equation 1-D.

$A_{Gj}$  = as determined in Equation 1-D.

$A_{Sj}$  = as determined in Equation 1-D.

$U_{Wjprop}$  = as determined in Equation 1-D.

$U_{Fjprop}$  = as determined in Equation 1-D.

$U_{Rjprop}$  = as determined in Equation 1-D.

$U_{Gjprop}$  = as determined in Equation 1-D.

$U_{Sjprop}$  = as determined in Equation 1-D.

$SHGC_{Gj}$  = the solar heat gain coefficient for the corresponding  $A_{Gj}$  (unitless).

$SHGC_{Sj}$  = the solar heat gain coefficient for the corresponding  $A_{Gj}$  (unitless).

$OHF_{Gj}$  = the overhang factor for the corresponding  $A_{Gj}$  (unitless).

$$OHF_{Gj} = 1 + aH/V + b(H/V)^2.$$

#### WHERE:

$H$  = horizontal projection of an overhang from the surface of the window, no greater than  $V_i$  in feet.

$V$  = vertical distance from the window sill to the bottom of the overhang, in feet.

$a$  = -0.41 for north-facing windows, -1.22 for south-facing windows, and -0.92 for east- and west-facing windows.

$b$  = 0.20 for north-facing windows, 0.66 for south-facing windows, and 0.35 for east- and west-facing windows.

$WF_{Gj}$  = the applicable weighting factor for each orientation of the building, from Table 1-K (unitless).

$WF_{Skyj}$  = the applicable weighting factor for skylight of the proposed building, from Table 1-K (unitless).

$WF_{Rj}$  = The applicable weighting factor for roof of the proposed building, from Table 1-K (unitless).

$\alpha_{Rjstd}$  = The applicable roof absorptivity for the corresponding  $A_{Rj}$ . An absorptivity of 0.45 for cool roofs (as defined in Section 118). An absorptivity of 0.7 for all other roofs.

$SF$  = the solar factor from Table 1-J.

$TF_j$  = the temperature factor from Table 1-J.

### SECTION 144 — PRESCRIPTIVE REQUIREMENTS FOR SPACE-CONDITIONING SYSTEMS

A building complies with this section by being designed with and having constructed and installed a space-conditioning system that meets the requirements of Subsections (a) through (h).

(a) **Sizing and Equipment Selection.** Mechanical heating and mechanical cooling equipment shall be the smallest size, within the available options of the desired equipment line, necessary to meet the design heating and cooling loads of the building, as calculated according to Subsection (b).

**EXCEPTION 1 to Section 144 (a):** Where it can be demonstrated to the satisfaction of the enforcing agency that oversizing will not increase building source energy use.

**EXCEPTION 2 to Section 144 (a):** Standby equipment with controls that allow the standby equipment to operate only when the primary equipment is not operating.

**EXCEPTION 3 to Section 144 (a):** Multiple units of the same equipment type, such as multiple chillers and boilers, having combined capacities exceeding the design load, if they have controls that sequence or otherwise optimally control the operation of each unit based on load.

(b) **Calculations.** In making equipment sizing calculations under Subsection (a), all of the following rules shall apply:

1. **Methodology.** The methodologies, computer programs, inputs, and assumptions approved by the commission shall be used.

2. **Heating and cooling loads.** Heating and cooling system design loads shall be determined in accordance with the procedures described in the ASHRAE Handbook, 1993, Fundamentals Volume, or as specified in a method approved by the commission.

3. **Indoor design conditions.** Indoor design temperature and humidity conditions for general comfort applications shall be determined in accordance with ANSI/ASHRAE 55-1992 or Chapter 8 of the ASHRAE Handbook, 1993, Fundamentals Volume, except that winter humidification and summer dehumidification shall not be required.

4. **Outdoor design conditions.** Outdoor design conditions shall be selected from ASHRAE publication SPCDX: Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, 1982. Heating design temperatures shall be no lower than the temperature listed in the Winter Median of Extremes column. Cooling design dry bulb temperatures shall be no greater than the tempera-

ture listed in the Summer Design Dry Bulb 0.5 percent column. Cooling design wet bulb temperatures shall be no greater than the temperature listed in the Summer Design Wet Bulb 0.5 percent column.

5. **Ventilation.** Outdoor air ventilation loads shall be calculated using the ventilation rates required in Section 121.

6. **Envelope.** Envelope heating and cooling loads shall be calculated using envelope characteristics, including square footage, thermal conductance, solar heat gain coefficient or shading coefficient, and air leakage, consistent with the proposed design.

7. **Lighting.** Lighting loads shall be based on actual design lighting levels or power densities consistent with Section 146.

8. **People.** Occupant density shall be based on the expected occupancy of the building and shall be the same as determined under Section 121 (b) 2 B, if used. Sensible and latent heat gains shall be as listed in ASHRAE Handbook, 1993, Fundamentals Volume, Chapter 26, Table 3.

9. **Process loads.** Loads caused by a process shall be based upon actual information on the intended use of the building.

10. **Miscellaneous equipment.** Equipment loads shall be calculated using design data compiled from one or more of the following sources:

- A. Actual information based on the intended use of the building; or
- B. Published data from manufacturer's technical publications and from technical societies, such as the ASHRAE Handbook, 1995, HVAC Applications Volume; or
- C. Other data based on the designer's experience of expected loads and occupancy patterns.

11. **Internal heat gains.** Internal heat gains may be ignored for heating load calculations.

12. **Safety factor.** Design loads may be increased by up to 10 percent to account for unexpected loads or changes in space usage.

13. **Other loads.** Loads such as warm-up or cool-down shall be calculated from principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be no more than 30 percent for heating and 10 percent for cooling of the steady-state design loads. The steady-state load may include a safety factor in accordance with Section 144 (b) 12.

(c) **Power Consumption of Fans.** Each fan system used for comfort space conditioning with a total fan power index over 25 horsepower shall meet the requirements of Item 1 or 2 below, as applicable. Total fan system power demand equals the sum of the power demand of all fans in the system that are required to operate at design conditions in order to supply air from the heating or cooling source to the conditioned space, and to return it back to the source or to exhaust it to the outdoors; however, total fan system power demand need not include the additional power demand caused solely by air treatment or filtering systems with final pressure drops more than 1-inch water column (only the energy accounted for by the amount of pressure drop that is over 1 inch may be excluded) or fan system power caused solely by process loads.

1. **Constant volume fan systems.** The total fan power index of each fan system at design conditions shall not exceed 0.8 watts per cubic feet per minute of supply air.

## 2. Variable air volume (VAV) systems.

- A. The total fan power index of each fan system at design conditions shall not exceed 1.25 watts per cubic feet per minute of supply air; and
- B. Individual VAV fans with motors over 25 horsepower shall meet one of the following:
  - i. The fan motor shall be driven by a mechanical or electrical variable speed drive.
  - ii. The fan shall be a vane-axial fan with variable pitch blades.
  - iii. For prescriptive compliance, the fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume when static pressure set point equals  $\frac{1}{3}$  of the total design static pressure, based on certified manufacturer's test data.

3. **Air-treatment or filtering systems.** For systems with air-treatment or filtering systems, calculate the adjusted fan power index using the following equation:

$$\text{Adjusted fan power index} = \text{Fan power index} \times \text{Fan adjustment}$$

$$\text{Fan Adjustment} = 1 - (SP_a/SP_f)$$

## WHERE:

$SP_a$  = Air pressure drop across the air-treatment or filtering system.

$SP_f$  = Total pressure drop across the fan.

(d) **Space-conditioning Zone Controls.** Each space-conditioning zone shall have controls that prevent:

1. Reheating; and
2. Recooling; and
3. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.

**EXCEPTION 1 to Section 144 (d):** Zones served by a variable air-volume system that is designed and controlled to reduce, to a minimum, the volume of reheated, recooled, or mixed air supply. For each zone, this minimum volume shall be no greater than the largest of the following:

- A. 30 percent of the peak supply volume; or
- B. The minimum required to meet the ventilation requirements of Section 121; or
- C. 0.4 cubic feet per minute (cfm) per square foot of conditioned floor area of the zone; or
- D. 300 cfm.

**EXCEPTION 2 to Section 144 (d):** Zones with special pressurization relationships or cross-contamination control needs.

**EXCEPTION 3 to Section 144 (d):** Zones served by space-conditioning systems in which at least 75 percent of the energy for reheating, or providing warm air in mixing systems, is provided from a site-recovered or site-solar energy source.

**EXCEPTION 4 to Section 144 (d):** Zones in which specific humidity levels are required to satisfy process needs.

**EXCEPTION 5 to Section 144 (d):** Zones with a peak supply-air quantity of 300 cfm or less.

## (e) Economizers.

1. Each individual cooling fan system that has a design supply capacity over 2,500 cfm and a total mechanical cooling capacity over 75,000 Btu/hr shall include either:

- A. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside air; or

- B. A water economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the commission, at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below.

**EXCEPTION 1 to Section 144 (e) 1:** Where it can be shown to the satisfaction of the enforcing agency that special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes compliance infeasible.

**EXCEPTION 2 to Section 144 (e) 1:** Where the use of outdoor air for cooling will affect other systems, such as humidification, dehumidification, or supermarket refrigeration systems, so as to increase overall building source energy use.

**EXCEPTION 3 to Section 144 (e) 1:** Systems serving high-rise residential living quarters and hotel/motel guest rooms.

**EXCEPTION 4 to Section 144 (e) 1:** Where it can be shown to the satisfaction of the enforcing agency that the use of outdoor air is detrimental to equipment or materials in a space or room served by a dedicated space-conditioning system, such as a computer room or telecommunications equipment room.

**EXCEPTION 5 to Section 144 (e) 1:** Where electrically operated unitary air conditioners and heat pumps have cooling efficiencies that meet or exceed the efficiency requirements of Tables 1-X1 and 1-X2.

2. If an economizer is required by subparagraph 1, it shall be:
- A. Designed and equipped with controls so that economizer operation does not increase the building heating energy use during normal operation; and
  - B. Capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

**EXCEPTION to Section 144 (e) 2 A:** Systems that provide 75 percent of the annual energy used for mechanical heating from site-recovered energy or a site-solar energy source.

3. Air-side economizers shall have high limit shutoff controls complying with Table 1-X3.

(f) **Supply Air Temperature Reset Controls.** Mechanical space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply-air temperatures:

1. In response to representative building loads or to outdoor air temperature; and
2. By at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Air distribution to zones that are likely to have constant loads, such as interior zones, shall be designed for the fully reset supply temperature.

**EXCEPTION 1 to Section 144 (f):** Systems that meet the requirements of Section 144 (d), without using Exception 1 or 2 to that section.

**EXCEPTION 2 to Section 144 (f):** Where supply-air temperature reset would increase overall building energy use.

**EXCEPTION 3 to Section 144 (f):** Zones in which specific humidity levels are required to satisfy process needs.

(g) **Electric Resistance Heating.** Electric resistance heating systems shall not be used for space heating.

**EXCEPTION 1 to Section 144 (g):** Where an electric resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirement is supplied by site-solar or recovered energy.

**EXCEPTION 2 to Section 144 (g):** Where an electric resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load calculated in accordance with Section 144 (a) at the design outdoor temperature specified in Section 144 (b) 4.

**EXCEPTION 3 to Section 144 (g):** Where the total capacity of all electric resistance heating systems serving the entire building is less

than 10 percent of the total design output capacity of all heating equipment serving the entire building.

**EXCEPTION 4 to Section 144 (g):** Where the total capacity of all electric resistance heating systems serving the building, excluding those allowed under Exception 2, is no more than 3 kW.

**EXCEPTION 5 to Section 144 (g):** Where an electric resistance heating system serves an entire building that:

- A. Is not a high-rise residential or hotel/motel building; and
- B. Has a conditioned floor area no greater than 5,000 square feet; and
- C. Has no mechanical cooling; and
- D. Is in an area where natural gas is not currently available and an extension of a natural gas system is impractical, as determined by the natural gas utility.

#### (h) Heat Rejection System Controls.

1. **General.** Section 144 (h) applies to heat rejection equipment used in comfort cooling systems, such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

2. **Fan speed control.** Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

**EXCEPTION to Section 144 (h):**

- A. Heat rejection devices included as an integral part of the equipment listed in Tables 1-C1 through 1-C4.
- B. Condenser fans serving multiple refrigerant circuits.
- C. Condenser fans serving flooded condensers.
- D. Up to one third of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

## SECTION 145 — PRESCRIPTIVE REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS

(a) **Nonresidential and Hotel/Motel Occupancies.** A service water-heating system installed in a nonresidential or hotel/motel building complies with this section if it complies with the applicable requirements of Sections 111, 113 and 123.

(b) **High-rise Residential Occupancies.** A service water-heating system installed in a high-rise residential building complies with this section if it complies with Section 151 (f) 8.

## SECTION 146 — PRESCRIPTIVE REQUIREMENTS FOR LIGHTING

A building complies with this section if its actual lighting power density calculated under Subsection (a) is no greater than the allowed lighting power density calculated under Subsection (b).

(a) **Calculation of Actual Lighting Power Density.** The actual lighting power of the proposed building area is the total watts of all planned permanent and portable lighting systems (including but not limited to, track and flexible lighting systems, lighting that is integral with modular furniture, workstation task lights, portable freestanding lights, lights attached to workstation panels, movable displays and cabinets, and internally illuminated case work for task or display purposes), subject to the following specific requirements and adjustments under Items 1 through 6.

1. In office areas, if the actual watts of portable lighting are not known at the time of permitting, the actual lighting power for portable and integral lighting shall be determined using either Item A or B following. However, upon installation of the portable lighting systems the building official may require resubmittal of compliance documentation using installed lighting and equipment data.

- A. In office areas greater than 250 square feet with permanently installed lighting systems, a portable lighting power of 0.2 watt per square foot shall be included in calculation of actual lighting power density.
  - B. In office areas of 250 square feet or less, no additional task lighting power will be required in the calculation of actual lighting power.
2. In office areas greater than 250 square feet with permanently installed lighting systems, if sufficient supporting evidence is submitted and accepted by the building official, the actual power for portable lighting shall be included in the calculation of actual lighting power. The individual signing the lighting plans, pursuant to Division 3 of the California Business and Professions Code, must clearly indicate on the plans the actual lighting power for the portable lighting systems in the area.
3. **Multiple interlocked lighting systems serving a space.** When multiple interlocked lighting systems serve a space, the watts of all systems except the system with the highest wattage may be excluded if:
- A. The lighting systems are interlocked to prevent simultaneous operation; or
  - B. The lighting systems are controlled by a preset dimming system or other device that prevents simultaneous operation of more than one lighting system, except under the direct control of authorized personnel.
4. **Reduction of wattage through controls.** The watts of any luminaire that is controlled may be reduced by the number of watts times the applicable factor from Table 1-L if:
- A. The control complies with Section 119; and
  - B. At least 50 percent of the light output of the luminaire is within the applicable space listed in Table 1-L; and
  - C. Except as noted in Table 1-L, only one power adjustment factor is used for the luminaire; and
  - D. For daylighting control credits, the luminaire is controlled by the daylighting control, and the luminaire is located within the daylight area.
5. **Lighting wattage excluded.** The watts of the following lighting applications may be excluded from the actual lighting power density of the building:
- A. Lighting for theme parks and special effects lighting for dance floors;
  - B. Lighting for film, video or photography studios;
  - C. Lighting for exhibits or for theatrical and other live performances, in exhibit, convention areas, and in hotel function areas, if the lighting is in addition to a general lighting system, and if the lighting is controlled by a multiscene or theatrical cross-fade control station accessible only to authorized operators;
  - D. Specialized local lighting installed in nonlighting equipment by its manufacturer;
  - E. In medical and clinical buildings, examination and surgical lights, low-level night lights, and lighting integral to medical equipment;
  - F. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment;
  - G. Interior lighting in refrigerated cases;
  - H. Lighting for plant growth or maintenance if it is equipped with an automatic 24-hour time switch that has program backup capabilities that prevent the loss of the

switch's program and time setting for at least 10 hours if power is interrupted;

- I. Lighting equipment that is for sale;
- J. Lighting demonstration equipment in lighting education facilities;
- K. Lighting that is required for exit signs subject to Section 1013 of the 1997 UBC if it has an input power rating of five watts per illuminated face or less;
- L. Exitway or egress illumination that is normally off and that is subject to Section 1012 of the 1997 UBC;
- M. Exitway or egress lighting whose switching is regulated by Article 3-700 of the California Electrical Code (Title 24, Part 3);
- N. In hotel/motel buildings, lighting in guest rooms;
- O. In high-rise residential buildings, lighting in living quarters;
- P. The lighting system using the least wattage in a redundant lighting system interlocked or otherwise controlled to prohibit simultaneous operation of more than one lighting system.

6. **Lighting fixtures.** The watts of track and other lighting fixtures that allow the substitution of low efficacy sources for high efficacy sources without altering the wiring of the fixture shall be determined in accordance with Section 130 (d) or by a method approved by the commission.

(b) **Calculation of Allowed Lighting Power Density.** The allowed lighting power density for each application for a building permit shall be calculated using one and only one of the methods in Subsection 1, 2 or 3, as applicable.

1. **Complete Building Method.** The Complete Building Method may be used only on projects involving entire buildings with one occupancy type or mixed occupancy buildings where one occupancy makes up 90 percent of the conditioned floor area of the entire building. This approach may only be used when the applicant is applying for a lighting permit for, and submits plans and specifications for, the entire building. Under this approach, the allowed lighting power density is the lighting power density value in Table 1-M times the conditioned floor area of the entire building. Hotel/motel and high-rise residential buildings shall not use this method.

2. **Area category method.** Under the Area Category Method, the total allowed lighting power for the building is the sum of all allowed lighting powers for all areas in the building. For purposes of the Area Category Method, an "area" shall be defined as all contiguous spaces which accommodate or are associated with a single one of the primary functions listed in Table 1-N. Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall be included in any area. When the area category method is used to calculate the allowed total lighting power for an entire building, main entry lobbies, corridors, restrooms, and support functions shall be treated as separate areas.

**EXCEPTION to Section 146 (b) 2:** The tailored method [Section 146 (b) 3] may be used for up to 10 percent of the floor area of a building that is otherwise using the Area Category Method. The two lighting methods cannot be used for the same floor area. The floor area for calculations based on the Tailored Method must be subtracted from the floor area for the remainder of the building lighting calculations. Trade-offs of lighting between the two methods is not allowed.

3. **Tailored method.** Under the Tailored Method, the allowed lighting power density shall be calculated as specified in Subsections (b) 3 A through I. Figure 1-B provides a flow chart of the calculations.

- A. Determine the illuminance category of each task space according to Table 1-P or, if the task is not listed in the table, according to the IES Handbook, Applications Volume (1987 edition), incorporated herein by reference. Selection of each illuminance category shall be justified on the plans submitted under Section 10-103 of Title 24, Part 1. Categories E through I may be used only if the plans submitted under Section 10-103 of Title 24, Part 1 clearly identify all task spaces for such categories and the lighting designed to illuminate them.
  - B. Determine the lighting power density value of each task space for categories A through D according to Table 1-S.
  - C. Determine the lighting power density value of each task space for categories E through I according to Table 1-S.
  - D. Determine the area, in square feet and as measured from the middle of interior partitions, of each task space that has a separate illuminance requirement. The illuminance category of the following spaces shall be limited as stated:
    - i. **Gross sales floor area.** The gross sales floor area shall be no more than 2.0 watts per square foot, plus the allocation for sales feature floor displays.
    - ii. **Sales feature floor displays.** Illuminance category G may be used for no more than 10 percent of the gross sales floor area of the building.
- EXCEPTION to Section 146 (b) 3 D ii:** For sales feature floor display lighting in stores with less than 800 square feet of gross sales area, 1,000 watts may be used.
- iii. **Gross sales wall area.** Gross sales wall areas shall be no more than 2.0 watts per square foot, plus the allocation for sales feature wall displays.
  - iv. **Sales feature wall displays.** Illuminance category G may be used for no more than 10 percent of the gross sales wall area.
  - v. **Private offices and work areas.** Illuminance category E may be used for up to 50 percent of the actual private office or work area; the rest of the private office or work area shall be no more than 0.4 watts per square foot.
  - vi. **Public area displays.** Illuminance category G may be used for no more than 10 percent of the public display area of the building.
- E. Multiply the lighting power density value of each task space for illuminance categories A through D (from Item B) times the area of each task space (from Item D).

For tasks where luminaires must be at or above a 15-foot mounting height, the result may be multiplied by the applicable figure from Table 1-R.

- F. Multiply the lighting power density value of each task space for illuminance categories E through I (from Item C) times the area of each task space (from Item D). For tasks where luminaires must be at or above a 15-foot mounting height, the result may be multiplied by the applicable figure from Table 1-R.
- G. For each task space, choose the smaller of:
  - i. The result in Item E plus the result in Item F; or
  - ii. The result in Item E plus the actual design watts of the lighting equipment used for task spaces for illuminance categories E through I and the gross sales wall area.
- H. The values obtained in Item G may be increased by the following:
  - i. **Very valuable merchandise.** For lighting of very valuable merchandise, the smaller of:
    - a. Twenty watts per square foot times the area of lighted case top; or
    - b. The actual design wattage of the lighting equipment for the merchandise.
  - ii. **Ornamental chandeliers and sconces.** For ornamental chandeliers and sconces in performance theater, religious worship, auditorium, mall, hotel function area, and lobby occupancy types, the smaller of:
    - a. Twenty watts per cubic foot times the volume of the chandelier or scone; or
    - b. One watt per square foot times the area of the task space that the chandelier or scone is in; or
    - c. The actual design wattage of the chandelier or scone.
- I. Add the results in Item G for all task spaces in the building plus the additional watts allowed in Item H. The result is the allowed lighting power of the building under the Tailored Method.

**SECTION 147 — Reserved.**

**SECTION 148 — Reserved.**

**TABLE 1-H—PRESCRIPTIVE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS**  
**(Except high-rise residential buildings and guest rooms of hotel/motel buildings)**

		CLIMATE ZONES									
		1,16		3-5		6-9		2, 10-13		14, 15	
<b>Roof/Ceiling</b>											
R-value or		19		19		11		19		19	
U-factor		0.057		0.057		0.078		0.057		0.057	
<b>Wall</b>											
R-value or		13		11		11		13		13	
U-factor											
Wood frame		0.084		0.092		0.092		0.084		0.084	
Metal frame		0.182		0.189		0.189		0.182		0.182	
Mass/7.0≤HC<15.0		0.340		0.430		0.430		0.430		0.430	
Mass/15.0≤HC		0.360		0.650		0.690		0.650		0.400	
Other		0.084		0.092		0.092		0.084		0.084	
<b>Floor/Soffit</b>											
R-value or		19		11		11		11		11	
U-factor											
Mass/7.0≤HC		0.097		0.158		0.158		0.097		0.158	
Other		0.050		0.076		0.076		0.076		0.076	
<b>Windows</b>											
U-factor		0.49		0.81		0.81		0.49		0.49	
Relative solar heat gain											
		Non-	North	Non-	North	Non-	North	Non-	North	Non-	North
0-10% WWR		0.49	0.72	0.61	0.61	0.61	0.61	0.47	0.61	0.46	0.61
11-20% WWR		0.43	0.49	0.55	0.61	0.61	0.61	0.36	0.51	0.36	0.51
21-30% WWR		0.43	0.47	0.41	0.61	0.39	0.61	0.36	0.47	0.36	0.47
31-40% WWR		0.43	0.47	0.41	0.61	0.34	0.61	0.31	0.47	0.31	0.40
<b>Skylights</b>											
U-factor											
	Glass w/Curb	0.99		1.18		1.18		0.99		0.99	
	Glass wo/Curb	0.57		0.68		0.68		0.57		0.57	
	Plastic w/Curb	0.87		1.30		1.30		1.10		1.10	
SHGC—Glass											
	0-2%	0.68		0.79		0.79		0.46		0.46	
	2.1-5%	0.46		0.40		0.40		0.36		0.36	
SHGC—Plastic											
	0-2%	0.77		0.79		0.77		0.77		0.71	
	2.1-5%	0.58		0.65		0.62		0.62		0.58	

**TABLE 1-I—PRESCRIPTIVE ENVELOPE CRITERIA FOR  
HIGH-RISE RESIDENTIAL BUILDINGS AND GUEST ROOMS OF HOTEL/MOTEL BUILDINGS**

		CLIMATE ZONES									
		1, 16		3-5		6-9		2, 10-13		14, 15	
<b>Roof/Ceiling</b>											
R-value or		30		19		19		30		30	
U-factor		0.037		0.051		0.051		0.037		0.037	
<b>Wall</b>											
R-value or		19		11		11		13		13	
U-factor											
Wood frame		0.063		0.092		0.092		0.084		0.084	
Metal frame		0.140		0.181		0.181		0.175		0.175	
Mass/7.0≤HC<15.0		0.340		0.430		0.430		0.430		0.430	
Mass/15.0≤HC		0.360		0.650		0.690		0.650		0.400	
Other		0.063		0.092		0.092		0.084		0.084	
<b>Floor/Soffit</b>											
R-value or		19		11		11		11		11	
U-factor											
Mass/7.0≤HC		0.097		0.158		0.158		0.097		0.097	
Other		0.050		0.076		0.076		0.076		0.076	
Raised concrete R-value		8		*		*		*		*	
<b>Windows</b>											
U-factor		0.49		0.49		0.49		0.49		0.49	
Relative solar heat gain											
		Non-	North	Non-	North	Non-	North	Non-	North	Non-	North
0-10% WWR		0.46	0.68	0.41	0.61	0.47	0.61	0.36	0.49	0.36	0.47
11-20% WWR		0.46	0.68	0.40	0.61	0.40	0.61	0.36	0.49	0.31	0.43
21-30% WWR		0.36	0.47	0.31	0.61	0.36	0.61	0.31	0.40	0.26	0.43
31-40% WWR		0.30	0.47	0.26	0.55	0.31	0.61	0.26	0.40	0.26	0.31
<b>Skylights</b>											
U-factor	Glass w/Curb	0.99		1.18		1.18		0.99		0.99	
	Glass wo/Curb	0.57		0.68		0.68		0.57		0.57	
	Plastic w/Curb	0.87		1.30		1.30		1.10		0.87	
SHGC—Glass	0-2%	0.46		0.58		0.61		0.46		0.46	
	2.1-5%	0.36		0.32		0.40		0.32		0.31	
SHGC—Plastic	0-2%	0.71		0.65		0.65		0.65		0.65	
	2.1-5%	0.55		0.39		0.65		0.34		0.27	

\*Required insulation levels for concrete raised floors are R-8 in Climate Zones 2, 11, 13 and 14; R-4 in Climate Zones 12 and 15, and R-0 in Climate Zones 3 through 10.

TABLE 1-J—TEMPERATURE AND SOLAR FACTORS

CLIMATE ZONE	TEMPERATURE FACTOR (TF) Envelope Construction			SOLAR FACTOR (SF) (Btu/hr-ft <sup>2</sup> )
	Light Mass	Medium Mass	Heavy Mass	
1	14	3	1	128
2	40	30	28	126
3	28	18	16	126
4	32	22	20	125
5	27	17	15	124
6	28	18	16	123
7	27	17	15	123
8	33	23	21	123
9	42	31	29	123
10	45	35	33	123
11	49	38	36	127
12	45	34	32	126
13	45	35	33	125
14	52	42	40	125
15	55	45	43	123
16	34	23	21	128

Light Mass: Heat Capacity < 7 Btu/ft<sup>2</sup> - °FMedium Mass: Heat Capacity > = 7 and <15 Btu/ft<sup>2</sup> - °FHeavy Mass: Heat Capacity > = 15 Btu/ft<sup>2</sup> - °FTABLE 1-K—GLAZING ORIENTATION WEIGHTING FACTORS ( $WF_G$ ), ( $WF_R$ ) and ( $WF_S$ )

CLIMATE ZONE	$WF_{north}$	$WF_{south}$	$WF_{west}$	$WF_{east}$	$WF_{sky}$	$WF_{roof}$
NONRESIDENTIAL						
1	0.56	1.25	1.16	1.03	1.48	0.93
2	0.56	1.30	1.18	0.96	2.34	1.12
3	0.51	1.28	1.24	0.97	2.42	0.84
4	0.55	1.20	1.24	1.01	2.53	0.96
5	0.58	1.25	1.18	0.98	2.48	0.80
6	0.56	1.23	1.21	1.00	2.40	0.84
7	0.57	1.30	1.17	0.97	2.36	0.87
8	0.60	1.26	1.14	1.00	2.47	0.98
9	0.56	1.36	1.11	0.97	2.29	0.97
10	0.60	1.38	1.07	0.95	2.19	1.02
11	0.55	1.19	1.17	1.10	2.37	0.89
12	0.55	1.17	1.21	1.07	2.40	0.92
13	0.58	1.15	1.17	1.10	2.39	1.04
14	0.57	1.17	1.20	1.07	2.46	1.13
15	0.61	1.27	1.05	1.07	2.29	0.92
16	0.51	1.27	1.15	1.07	2.20	1.03
HIGH-RISE RESIDENTIAL						
1	0.50	1.24	1.23	1.03	1.36	0.82
2	0.55	1.29	1.23	0.94	2.30	1.08
3	0.47	1.28	1.29	0.96	2.42	0.80
4	0.54	1.17	1.33	0.96	2.53	0.96
5	0.49	1.28	1.25	0.97	2.48	0.77
6	0.55	1.20	1.26	0.99	2.37	0.79
7	0.55	1.28	1.21	0.96	2.37	0.88
8	0.57	1.26	1.20	0.97	2.44	0.96
9	0.53	1.39	1.14	0.94	2.24	0.93
10	0.59	1.34	1.12	0.94	1.92	1.00
11	0.53	1.14	1.27	1.06	2.23	0.88
12	0.55	1.14	1.29	1.03	2.31	0.91
13	0.57	1.12	1.27	1.05	2.27	1.02
14	0.57	1.13	1.28	1.02	2.38	1.08
15	0.59	1.26	1.12	1.03	2.26	0.90
16	0.49	1.24	1.25	1.01	2.02	0.95

TABLE 1-L—LIGHTING POWER ADJUSTMENT FACTORS

TYPE OF CONTROL	TYPE OF SPACE		FACTOR
Occupant sensor with separate sensor for each space	Any space $\leq$ 250 square feet enclosed by opaque floor-to-ceiling partitions; any size classroom, corridor or conference or waiting room		0.20
	Rooms of any size that are used exclusively for storage		0.60
	Greater than 250 square feet		0.10
Dimming system Manual	Hotels/motels, restaurants, auditoriums, theaters		0.10
Multiscene programmable	Hotels/motels, restaurants, auditoriums, theaters		0.20
Tuning	Any space		0.10
Automatic time switch control device	< 250 square feet and with a timed manual override at each switch location required by Section 131 (a), and controlling only the lights in the area enclosed by ceiling-height partitions.		0.05
Combined controls  Occupant sensor with programmable multiscene dimming system  Occupant sensor with a separate sensor for each space used in conjunction with daylighting controls and separate sensor for each space	Hotels/motels, restaurants, auditoriums, theaters		0.35
	Any space $\leq$ 250 square feet within a daylit area and enclosed by opaque floor-to-ceiling partitions		0.10 (may be added to daylighting control credit)
Automatic Daylighting Controls (Stepped/Dimming)			
	WINDOWS Window Wall Ratio		
Glazing Type	< 20%	20% to 40%	> 40 %
VLT $\geq$ 60% VLT $\geq$ 35 and < 60% VLT < 35%	0.20/0.30 0/0 0/0	0.30/0.40 0.20/0.30 0/0	0.40/0.40 0.30/0.40 0.20/0.40
	SKYLIGHTS Percentage of Gross Exterior Roof Area		
Glazing Type	< 1%	1% to 3%	> 3%
VLT $\geq$ 60% VLT $\geq$ 35 and < 60% VLT < 35%	0/0.30 0/0.20 0/0.10	0.15/0.40 0/0.30 0/0.20	0.30/0.40 0.15/0.40 0/0.30

TABLE 1-M—COMPLETE BUILDING METHOD—LIGHTING POWER DENSITY VALUES (Watts/ft<sup>2</sup>)

TYPE OF USE	ALLOWED LIGHTING POWER
General commercial and industrial work buildings	
High bay	1.2
Low bay	1.0
Grocery stores	1.5
Industrial and commercial storage buildings	0.7
Medical buildings and clinics	1.2
Office buildings	1.2
Religious facilities and auditoriums	1.8
Convention centers	1.4
Restaurants	1.2
Retail and wholesale stores	1.7
Schools	1.4
Theaters	1.3
All others	0.6

**TABLE 1-N—AREA CATEGORY METHOD—LIGHTING POWER DENSITY VALUES (Watts/ft<sup>2</sup>)**

PRIMARY FUNCTION	ALLOWED LIGHTING POWER
Auditorium	2.0*
Auto repair	1.2
Bank/financial institution	1.4
Classrooms, lecture, training, vocational room	1.6
Commercial and industrial storage	0.6
Convention, conference, multipurpose and meeting centers	1.5*
Corridors, restrooms, stairs and support areas	0.6
Dining	1.1*
Electrical, mechanical rooms	0.7
Exercise center, gymnasium	1.0
Exhibit, museum	2.0
General commercial and industrial work	
High bay	1.2
Low bay	1.0
Grocery store	1.6
Hotel function area	2.2*
Kitchen, food preparation	1.7
Laundry	0.9
Library	
Reading areas	1.2
Stacks	1.5
Lobbies:	
Hotel lobby	1.7*
Main entry lobby	1.5*
Reception/waiting	1.1*
Locker/dressing room	0.8
Lounge/recreation	1.1
Malls, arcades and atria	1.2*
Medical and clinical care	1.4
Office	1.3
Precision commercial or industrial work	1.5
Religious worship	2.1*
Retail sales, wholesale showrooms	2.0
Theaters	
Motion picture	0.9
Performance	1.4*
All other	0.6

\*The smallest of the following values may be added to the allowed lighting power listed in Table 1-N for ornamental chandeliers and sconces that are switched or dimmed on circuits different from the circuits for general lighting:

- Twenty watts per cubic foot times the volume of the chandelier or sconce; or
- One watt per square foot times the area of the task space that the chandelier or sconce is in; or
- The actual design wattage of the chandelier or sconce.

**TABLE 1-P—ILLUMINANCE CATEGORIES FOR TASKS**

TASK AREA	ILLUMINANCE CATEGORY
Church	
Altar, ark, reredos	E
Choir and chancel	D
Main worship area	D
Pulpit, rostrum	E
Dining	D
Office	D*
Public area displays	G
Sales feature displays	G

\*Office Lighting American National Standard Practice ANSI/IES RP-1, 1993, shall be used to determine the illuminance category for each office task area that requires an illuminance level higher than category D. The illuminance category for visual task requirements selected for each office task area shall not be based on:

- Poor quality tasks that can be improved; or
- Tasks that are performed for less than two hours per day.

**TABLE 1-R—MOUNTING HEIGHT MULTIPLIERS**

REQUIRED MOUNTING HEIGHT (Feet)	MULTIPLIER
15	1.15
16	1.21
17	1.47
18	1.65
19	1.84
20 or more	2.04

TABLE 1-S—ILLUMINANCE CATEGORIES A THROUGH I—LIGHTING POWER DENSITY VALUES (Watts/ft<sup>2</sup>)

ILLUMINANCE CATEGORY	ROOM CAVITY RATIO		
	0 to < 3.5	≥ 3.5 to < 7	≥ 7 +
A	0.2	0.3	0.4
B	0.4	0.5	0.7
C	0.6	0.7	1.1
D	0.99	1.24	1.49
E	2.31	2.97	3.88
	Task area ≤ 2 ft <sup>2</sup> or throw distance > 8 ft		Task area > 2 ft <sup>2</sup> and throw distance ≤ 8 ft
F	9.0		4.5
G	23.4		11.7
H	56.7		29.7
I	117.0		58.5

TABLE 1-X1—ECONOMIZER TRADEOFF TABLE FOR ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS

CLIMATE ZONE	SIZE CATEGORY			
	≥760,000	≥240,000 and <760,000	≥135,000 and <240,000	≥65,000 and <135,000
1	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A
4	11.9	12.2	12.4	N/A
5	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A
8	11.9	12.2	12.4	N/A
9	11.6	11.9	12.1	N/A
10	11.4	11.7	11.9	12.4
11	11.5	11.8	12.0	N/A
12	11.7	12.0	12.2	N/A
13	11.2	11.5	11.7	12.3
14	11.7	12.0	12.2	N/A
15	10.0	10.4	10.6	11.3
16	N/A	N/A	N/A	N/A

TABLE 1-X2—ECONOMIZER TRADEOFF TABLE FOR ELECTRICALLY OPERATED UNITARY HEAT PUMPS

CLIMATE ZONE	SIZE CATEGORY		
	≥240,000	≥135,000 and <240,000	≥65,000 and <135,000
1	N/A	N/A	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	11.7	12.1	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	12.3	N/A	N/A
8	11.7	12.0	N/A
9	11.3	11.7	12.5
10	11.1	11.5	12.3
11	11.3	11.6	12.4
12	11.5	11.8	N/A
13	10.9	11.3	12.1
14	11.5	11.8	N/A
15	9.8	10.1	11.1
16	N/A	N/A	N/A

TABLE 1-X3—AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

DEVICE TYPE	CLIMATE ZONES	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
		Equation	Description
Fixed dry bulb	1, 2, 3, 5, 11, 13, 14, 15 and 16	$T_{OA} > 75^{\circ}\text{F}$	Outside air temperature exceeds $75^{\circ}\text{F}$
	4, 6, 7, 8, 9, 10 and 12	$T_{OA} > 70^{\circ}\text{F}$	Outside air temperature exceeds $70^{\circ}\text{F}$
Differential dry bulb	All	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed enthalpy <sup>1</sup>	4, 6, 7, 8, 9, 10 and 12	$h_{OA} > 28 \text{ Btu/lb}^2$	Outside air enthalpy exceeds 28 Btu/lb of dry air <sup>2</sup>
Electronic enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the "A" set-point curve <sup>3</sup>
Differential enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy

<sup>1</sup>Fixed enthalpy controls are prohibited in climate zones 1, 2, 3, 5, 11, 13, 14, 15 and 16.

<sup>2</sup>At altitudes substantially different than sea level, the fixed enthalpy limit value shall be set to the enthalpy value at  $75^{\circ}\text{F}$  and 50 percent relative humidity. As an example, at approximately 6000-foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

<sup>3</sup>Set point "A" corresponds to a curve on the psychometric chart that goes through a point at approximately  $75^{\circ}\text{F}$  and 40 percent relative humidity and is nearly parallel to dry bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

FIGURE 1-B—DETERMINING ALLOCATIONS WITHIN THE  
TAILORED METHOD IN SECTION 146 (b) 3

STEP	ILLUMINANCE CATEGORY	
	A-D	E-I
	See the following subsections	
Determine illuminance categories for each space	(b) 3 A	(b) 3 A
Determine LPD value for each space	(b) 3 B	(b) 3 C
Determine area of each space	(b) 3 D	(b) 3 D
Determine total watts for each space	(b) 3 E	(b) 3 F
Determine allowed watts for each space	(b) 3 G	(b) 3 G
Determine additional allotments allowed	(b) 3 H	(b) 3 H
Determine allowed power density of the building	(b) 3 I	(b) 3 I

## SUBCHAPTER 6

### NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES—ADDITIONS, ALTERATIONS, AND REPAIRS

#### SECTION 149 — ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING BUILDINGS THAT WILL BE NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES

(a) **Additions.** Additions shall meet either Item 1 or 2 below.

1. **Prescriptive approach.** The envelope and lighting of the addition, and any newly installed space-conditioning or water-heating system serving the addition, shall meet the applicable requirements of Sections 110 through 139, and Sections 142 through 146.

2. **Performance approach.**

- A. The envelope and lighting of the addition, and any newly installed space-conditioning or water-heating system serving the addition, shall meet the applicable requirements of Sections 110 through 139; and
- B. Either:
  - i. The addition alone shall comply with Section 141; or
  - ii. The energy efficiency of the existing building shall be improved so that the entire building meets the energy budget in Section 141 that would apply to the entire building if the existing building was unchanged and the addition alone complied with Item 1.

**EXCEPTION 1 to Section 149 (a):** When heating, cooling or service water heating to an addition are provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110 through 129, or Sections 144 through 145.

**EXCEPTION 2 to Section 149 (a):** Where an existing system with electric reheat is expanded by adding variable air volume (VAV) boxes to serve an addition, total electric reheat capacity may be expanded not to exceed 50 percent of the existing installed electric heating capacity in any one permit and the system need not comply with Section 144 (g). Additional electric reheat capacity in excess of 50 percent may be added subject to the requirements of the Section 144 (g).

(b) **Alterations.** Alterations to existing nonresidential, high-rise residential, or hotel/motel buildings or alterations in conjunction with a change in building occupancy to a nonresidential, high-rise residential or hotel/motel occupancy not subject to Subsection (a) shall meet either Item 1, 2 or 3 below.

1. **Prescriptive approach.** The altered envelope, space conditioning, lighting and water heating components, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110 through 132; and

- A. Alterations to the building envelope shall:
  - i. Neither increase the overall heat gain nor increase the overall heat loss of the building envelope for which a permit is sought; or
  - ii. Meet the requirements of Section 143 for the altered component; and
- B. New space-conditioning systems shall meet the requirements of Section 144; and

- C. New lighting systems installed in conjunction with an increase in conditioned floor area, such as adding a mezzanine, shall meet the requirements of Section 146; and
- D. Alterations to existing lighting systems that increase the connected lighting load or replace more than 50 percent of the lighting fixtures shall meet the requirements of Section 146; and
- E. New service water-heating systems shall meet the requirements of Section 145.

**EXCEPTION to Section 149 (b) 1 A ii:** When a portion of an entire building's fenestration is repaired or replaced, or 50 square feet or less of glass is added, compliance with the solar heat gain coefficient requirements of Section 143 is not required.

2. **Performance approach.**

- A. The altered envelope, space conditioning, lighting and water heating components, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110 through 139; and
- B. Either:
  - i. The permitted space alone shall comply with Section 141; or
  - ii. The energy efficiency of the existing building shall be improved so that the entire building meets the energy budget in Section 141 that would apply to the entire building, if the existing building was unchanged and the permitted space alone complied with Item i above.

3. **Semiconditioned nonresidential buildings.** The altered lighting components and any newly installed lighting equipment serving the alteration within an existing semiconditioned space, shall meet the applicable requirements of Sections 119, and 130 through 132. Alterations to existing lighting systems that increase the connected lighting load or replace more than 50 percent of the lighting fixtures shall meet the requirements of Section 146.

**EXCEPTION 1 to Section 149 (b):** When heating, cooling or service water heating for an alteration are provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110 through 129 and Section 144 or 145.

**EXCEPTION 2 to Section 149 (b):** When existing heating, cooling or service water heating systems or components are moved within a building, the existing systems or components need not comply with Sections 110 through 129 and Section 144 or 145.

**EXCEPTION 3 to Section 149 (b):** Where an existing system with electric reheat is expanded when adding variable air volume (VAV) boxes to serve an alteration, total electric reheat capacity may be expanded not to exceed 20 percent of the existing installed electric capacity in any one permit and the system need not comply with Section 144 (g). Additional electric reheat capacity in excess of 20 percent may be added subject to the requirements of Section 144 (g).

(c) **Repairs.** Repairs shall not increase the preexisting energy consumption of the repaired component, system or equipment.

(d) **Alternate Method of Compliance.** Any addition, alteration or repair may comply with the requirements of Title 24, Part 6 by meeting the applicable requirements for the entire building.



## SUBCHAPTER 7

### LOW-RISE RESIDENTIAL BUILDINGS—MANDATORY FEATURES AND DEVICES

#### SECTION 150 — MANDATORY FEATURES AND DEVICES

Any new construction in a low-rise residential building shall meet the requirements of this section.

(a) **Ceiling Insulation.** The opaque portions of ceilings separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either Item 1 or 2 below:

1. Ceilings shall be insulated between wood-framing members with insulation resulting in an installed thermal resistance of R-19 or greater for the insulation alone.

**ALTERNATIVE to Section 150 (a) 1:** Insulation which is not penetrated by framing members may meet an R-value equivalent to installing R-19 insulation between wood-framing members and accounting for the thermal effects of framing members.

2. The weighted average U-factor of ceilings shall not exceed the U-factor that would result from installing R-19 insulation between wood-framing members in the entire ceiling and accounting for the effects of framing members.

(b) **Loose-fill Insulation.** When loose-fill insulation is installed, the minimum installed weight per square foot shall conform with the insulation manufacturer's installed design weight per square foot at the manufacturer's labeled R-value.

(c) **Wall Insulation.** The opaque portions of frame walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either Item 1 or 2 below:

1. Wood-framed walls shall be insulated between framing members with insulation having an installed thermal resistance of R-13 or greater. Framed foundation walls of heated basements or heated crawl spaces shall be insulated above the adjacent outside ground line with insulation having an installed thermal resistance of at least R-13.

**ALTERNATIVE to Section 150 (c) 1:** Insulation which is not penetrated by framing members may meet an R-value equivalent to installing R-13 insulation between wood-framing members and accounting for the thermal effects of framing members.

2. The weighted average U-factor of walls shall not exceed the U-factor that would result from installing R-13 insulation between wood-framing members and accounting for the effects of framing members.

(d) **Raised-floor Insulation.** Raised floors separating conditioned space from unconditioned space shall meet the requirements of either Item 1 or 2 below:

1. Floors shall be insulated between wood-framing members with insulation having an installed thermal resistance of R-13 or greater.

2. The weighted average U-factor of floor assemblies shall not exceed the U-factor that would result from installing R-13 insulation between wood-framing members and accounting for the effects of framing members.

**ALTERNATIVE to Section 150 (d) 1 and 2:** Raised floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Tables 1-Z1 through 1-Z16, a vapor barrier is placed over the entire floor of the crawl space, and vents are fitted with automatically operated louvers that are temperature actuated.

(e) **Installation of Fireplaces, Decorative Gas Appliances and Gas Logs.**

1. If a masonry or factory-built fireplace is installed, it shall have the following:

- A. Closable metal or glass doors covering the entire opening of the firebox;
- B. A combustion air intake to draw air from the outside of the building directly into the firebox, which is at least 6 square inches in area and is equipped with a readily accessible, operable and tight-fitting damper or combustion-air control device; and

**EXCEPTION to Section 150 (e) 1 B:** An outside combustion-air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.

- C. A flue damper with a readily accessible control.

**EXCEPTION to Section 150 (e) 1 C:** When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.

2. Continuous burning pilot lights and the use of indoor air for cooling a firebox jacket, when that indoor air is vented to the outside of the building, are prohibited.

(f) **Infiltration Barrier.** If an infiltration barrier is installed to meet the requirements of Section 151, it must have an air porosity of less than 5 ft<sup>3</sup> per hour per square foot per inch of mercury pressure difference when tested in accordance with the requirements of ASTM E 283-91. If a vapor barrier functions as an infiltration barrier it shall be located on the conditioned side of the exterior framing.

(g) **Vapor Barriers.** In Climate Zones 14 and 16 shown in Figure 1-A, a vapor barrier shall be installed on the conditioned space side of all insulation in all exterior walls, unvented attics and unvented crawl spaces to protect insulation from condensation.

If a building has a control ventilation crawl space, a vapor barrier shall be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation, as specified in the alternative to Section 150 (d).

(h) **Space-conditioning Equipment.**

1. Building design heat loss rate and design heat gain rate shall be determined using a method based on any one of the following:

- A. The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Handbook and Product Directory, Equipment Volume (1996), HVAC Applications Volume (1995), and Fundamentals Volume (1993), or
- B. The Sheet Metal Air Conditioning Contractors National Association (SMACNA) Installation Standards for Residential Heating and Air Conditioning Systems, or
- C. The Air Conditioning Contractors of America (ACCA) Manual J.

The design heat loss rate and design heat gain rate are two of the criteria that shall be used for equipment sizing and selection.

**NOTE to Section 150 (h) 1:** Heating systems must meet the minimum heating capacity required by UBC Section 310.11. The furnace output capacity and other specifications are published in the commission's directory of certified equipment or other directories approved by the commission.

2. **Design conditions.** For the purpose of sizing the space-conditioning (HVAC) system, the indoor design temperatures shall be 70°F for heating and 78°F for cooling. The outdoor design temperatures for heating shall be no lower than the Winter Median of Extremes column. The outdoor design temperatures for cooling shall be from the 0.5 percent Summer Design Dry Bulb and the 0.5 percent Wet Bulb columns for cooling, based on percent-of-year in ASHRAE publication *SPCDX: Climate Data for Region X, Arizona, California, Hawaii, and Nevada*, 1982, incorporated herein by reference.

(i) **Setback Thermostats.** All heating and/or cooling systems other than wood stoves shall have an automatic thermostat with a clock mechanism or other setback mechanism approved by the executive director that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least two periods within 24 hours.

**EXCEPTION to Section 150 (i):** Gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, room air conditioners, and room air-conditioner heat pumps need not comply with this requirement. Additionally, room air-conditioner heat pumps need not comply with Section 112 (b). The resulting increase in energy use due to elimination of the setback thermostat shall be factored into the compliance analysis in accordance with a method prescribed by the executive director.

### (j) Pipe and Tank Systems.

#### 1. Storage tank insulation.

- A. Storage gas water heaters with an energy factor < 0.58 shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater.
- B. Unfired hot water tanks, such as storage tanks and back-up storage tanks for solar water-heating systems, shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater or have internal insulation of at least R-16 and a label on the exterior of the tank showing the insulation R-value.

2. Piping, whether buried or unburied, for recirculating sections of domestic hot water systems, piping from the heating source to the storage tank for an indirect-fired domestic water-heating system, cooling system piping below 55°F, and the first 5 feet of hot and cold water pipes from the storage tank for nonrecirculating systems shall be thermally insulated in accordance with Table 1-T.

**EXCEPTION to Section 150 (j) 2:** The following piping does not have to be thermally insulated:

- A. Factory-installed piping within space-conditioning equipment; and
- B. Piping that conveys fluids that have a design operating temperature range between 55°F and 105°F.

**NOTE to Section 150 (j) 2:** Where the executive director approves a water heater calculation method for a particular water heating recirculation system, piping insulation requirements shall be those specified in the approved calculation method.

3. **Insulation Protection.** Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, including but not limited to, the following:

Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides

shielding from solar radiation that can cause degradation of the material.

Insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

4. Solar water-heating systems and/or collectors shall be certified by the Solar Rating and Certification Corporation.

### (k) Lighting.

1. Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. General lighting must provide a sufficient light level for basic kitchen tasks and provide a uniform pattern of illumination. A luminaire(s) that is (are) the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.

Additional luminaires to be used only for specific decorative effects need not meet this requirement.

2. Each room containing a shower or bathtub shall have at least one luminaire with lamp(s) with an efficacy of 40 lumens per watt or greater. If there is more than one luminaire in the room, the high-efficacy luminaire shall be switched at an entrance to the room.

**ALTERNATIVE to Section 150 (k) 2:** A high-efficacy luminaire need not be installed in a bathroom if:

- A. A luminaire with lamps with an efficacy of 40 lumens per watt or greater is installed in a utility room, laundry room, or garage; and
- B. All luminaires permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:
  - (1) Luminaires with lamps with 40 lumens per watt or greater; or
  - (2) Luminaires with lamps with an efficacy of less than 40 lumens per watt shall be equipped with a motion sensor.

**NOTE:** When using this alternative for multiple bathrooms, after complying with Item B for the first bathroom, each additional bathroom in which a high-efficacy luminaire is not installed must comply with Item A alone.

3. Luminaires installed to meet the 40 lumens per watt requirements of Section 150 (k) 1 or 2 shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.

4. All incandescent lighting fixtures recessed into insulated ceilings shall be approved for zero-clearance insulation cover (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials.

(l) **Slab Edge Insulation.** Material used for slab edge insulation shall meet the following minimum specifications:

1. Water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C 271-94.
2. Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM E 96-95.
3. Concrete slab perimeter insulation must be protected from physical damage and ultraviolet light deterioration.

### (m) Air-distribution System Ducts, Plenums and Fans.

1. **CMC compliance.** All air-distribution system ducts and plenums, including but not limited to, mechanical closets and air-handler boxes, shall be installed, sealed and insulated to meet the requirements of the 1998 CMC Sections 601, 603 and 604 and Standard 6-3<sup>4</sup>, incorporated herein by reference. Portions conveying conditioned air shall either be insulated to a minimum in-

<sup>4</sup>On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct insulation, sealing and insulation shall comply with Sections 601, 602, 604, 605 and Standard 6-5 of the 2000 CMC.

stalled level of R-4.2 (or any higher level required by CMC Section 604<sup>5</sup>) or be enclosed entirely in conditioned space. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

Building cavities, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross-sectional area of the ducts.

## 2. Factory-fabricated duct systems.

- A. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices.
- B. All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181.
- C. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 or UL 181B.
- D. Joints and seams of duct systems and their components shall not be sealed with cloth-back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

## 3. Field-fabricated duct systems.

- A. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A or UL 181B.
- B. **Mastic sealants and mesh.**
  - i. Sealants shall comply with UL 181, UL 181A or UL 181B, and be nontoxic and water resistant.
  - ii. Sealants for interior applications shall pass ASTM tests C 731 (extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.
  - iii. Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.
  - iv. Sealants and meshes shall be rated for exterior use.
- C. **Pressure-sensitive tape.** Pressure-sensitive tapes shall comply with UL 181, UL 181A, or UL 181B.
- D. Joints and seams of duct systems and their components shall not be sealed with cloth-back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.
- E. **Drawbands used with flexible duct.**
  - i. Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.

- ii. Drawbands shall have a minimum tensile strength rating of 150 pounds.
- iii. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

## F. Aerosol-sealant closures.

- i. Aerosol sealants shall meet the applicable requirements of UL 181, UL 181A or UL 181B and be applied according to manufacturer specifications.
- ii. Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

4. All duct insulation product R-values shall be based on insulation only (excluding air films, vapor barriers or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C 518-85 or ASTM C 177-85, incorporated herein by reference, and certified pursuant to Section 118.

5. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

- A. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
- B. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.
- C. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

6. Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor barriers or other duct components), based on the tests in Section 150 (m) 4 and the installed thickness determined by Section 150 (m) 5 C.

7. All fan systems, regardless of volumetric capacity, that exhaust air from the building to the outside shall be provided with backdraft or automatic dampers to prevent air leakage.

8. All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.

9. **Protection of insulation.** Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

**EXCEPTION to Section 150 (m) 1:** The requirements do not apply to ducts and fans integral to a wood heater or fireplace.

**NOTE:** Authority cited: Public Resources Code, Sections 25218 (e), 25402 and 25402.1. Reference: Public Resources Code, Section 25402.

<sup>5</sup>On and after the effective date designated by the California Building Standards Commission for the 2000 CMC, duct insulation shall comply with Section 605 of the 2000 CMC.

**TABLE 1-T—PIPE INSULATION REQUIREMENTS—MINIMUM R-VALUE**

SYSTEM	PIPE DIAMETER	
	Less than or Equal to 2 Inches	Greater than 2 Inches
Domestic hot water	R-4	R-6
Hydronic heating supply lines	R-4	R-6
Cooling systems (pipes below 55°F)	R-3	R-4

## SUBCHAPTER 8

### LOW-RISE RESIDENTIAL BUILDINGS—PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

#### SECTION 151 — PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

(a) **Basic Requirements.** New low-rise residential buildings shall meet all of the following:

1. The requirements of Sections 111 through 118 applicable to new residential buildings.
2. The requirements of Section 150 (mandatory features).
3. Either the performance standards (energy budgets) or the prescriptive standards (alternative component packages) set forth in this section for the climate zone in which the building will be located. Climate zones are shown in Figure 1-A.

**ALTERNATIVE to Section 151 (a) 3:** If a single contiguous subdivision or tract falls in more than one climate zone, all buildings in the subdivision or tract may be designed to meet the performance or prescriptive standards for the climate zone which contains 50 percent or more of the dwelling units.

**NOTE to Section 151 (a) 3:** The California Energy Commission shall periodically update, publish and make available to interested persons and local building departments a document entitled *California Climate Zone Descriptions for New Buildings*, (July 1995), which shall contain a precise description of the metes and bounds for climate zone boundaries depicted in Figure 1-A and a list of the communities in each zone.

4. For other provisions applicable to new low-rise residential buildings, refer to Section 100 (c).

(b) **Performance Standards.** A building complies with the performance standard if its combined calculated depletable energy use for water heating [Section 151 (b) 1] and space conditioning [Section 151 (b) 2] is less than or equal to the combined maximum allowable energy use for both water heating and space conditioning, even if the building fails to meet either the water heating or space conditioning budget alone.

1. **Water-heating budgets.** The budgets for water-heating systems are those calculated from Equation (1-N).

#### EQUATION (1-N)—ANNUAL WATER-HEATING BUDGET (AWB) EQUATION

For dwelling units less than 2,500 ft.<sup>2</sup>:

$$AWB \text{ (kBtu/yr. - ft.}^2\text{)} = \frac{(16370)}{CFA} + 4.85 \quad (1-N)$$

For dwelling units equal to or greater than 2,500 ft.<sup>2</sup>:

$$AWB \text{ (kBtu/yr. - ft.}^2\text{)} = \frac{(26125)}{CFA}$$

#### WHERE:

*CFA* = the building's conditioned floor area in square feet.

The annual water-heating budget calculated from Equation (1-N) may be met by either:

- A. Calculating the energy consumption of the proposed water-heating system using an approved calculation method without an external insulation wrap; or
- B. Installing any gas storage-type nonrecirculating water-heating system that does not exceed 50 gallons of capacity, and that meets the minimum standards specified in the Appliance Efficiency Standards.

**NOTE:** Storage gas water heaters with an energy factor of less than 0.58 must be externally wrapped with insulation having an installed thermal resistance of R-12 or greater in accordance with Section 150 (j).

2. **Space-conditioning budgets.** The space-conditioning budgets for each climate zone shall be the calculated consumption of energy from depletable sources required for space conditioning in buildings in which the basic requirements of Section 151 (a) and the measures in alternative component package D are installed. To determine the space-conditioning budget, use an approved calculation method.

(c) **Compliance Demonstration Requirements for Performance Standards.** The application for a building permit shall include documentation which demonstrates, using an approved calculation method, that the new building has been designed so that its energy use from depletable energy sources does not exceed the combined water-heating and space-conditioning energy budgets for the appropriate climate zone.

1. To demonstrate compliance, the applicant's documentation shall:

- A. Determine the combined energy budget for the proposed building by adding the following:
  - i. The annual water-heating budget calculated from Equation (1-N) (kBtu/yr.-ft.<sup>2</sup>) and
  - ii. The annual space-conditioning budget (kBtu/yr.-ft.<sup>2</sup>) as determined pursuant to Section 151 (b) 2.
- B. Calculate the source energy consumption total of the proposed building, using the proposed building's actual glazing area, orientation and distribution, and its actual energy conservation and other features, including the actual water-heating, space-conditioning equipment and duct conditions and locations.

Include in the calculation the energy required for building cooling even if the building plans do not indicate that air conditioning will be installed.

2. The proposed building design complies if the energy consumption calculated pursuant to Section 151 (c) 1 B is equal to or less than the combined energy budget established in Section 151 (c) 1 A.

#### MULTIPLE ORIENTATION ALTERNATIVE to Section 151

(c): A permit applicant may demonstrate compliance with the energy budget requirements of Section 151 (a) and (b) for any orientation of the same building model if the documentation demonstrates that the building model with its proposed designs and features would comply in each of the four cardinal orientations.

- (d) **Compliance Methods for Performance Standards.** Compliance with the energy budget requirements of Section 151 (a) 3 and (b) must be demonstrated by using the compliance version of the commission's Public Domain Computer Program or any alternative calculation method approved by the commission for use in complying with Section 151 (a) and (b).

**NOTE:** Compliance with the water-heating budget need not be demonstrated using any of the calculation methods referred to in Section 151 (d), if all the requirements of Section 151 (b) 1 B are met.

- (e) **Required Calculation Assumptions.** The commission shall publish the assumptions and calculation methods it used to develop the standards for low-rise residential buildings, including

those specified in Section 151. In determining the water-heating and space-conditioning budgets and calculating the energy use of the proposed building design, the applicant shall use only these assumptions and calculation methods (or alternative assumptions and methods approved by the commission or its executive director).

1. Such assumptions shall include, but not be limited to, the following:

- A. The operating conditions regarding indoor temperature; occupancy loads and schedules; equipment loads and operation schedules, including lighting, HVAC, and miscellaneous electrical; and outdoor weather conditions;
- B. The physical characteristics of building pressurization, interior heat transfer, film coefficients, solar heat gain coefficient and operation of installed shading devices, ground temperatures, and the method of determining slab heat loss;
- C. The applicable modeling procedures for the assumptions, design conditions, and physical characteristics described in Section 151 (e) 1.

**EXCEPTION to Section 151 (e) 1:** The commission may approve alternative schedules, assumptions, and performance modeling procedures that may be used in lieu of those described in Section 151 (e) 1, provided such alternatives do not alter the efficiency level required by these standards.

2. The total calculated annual energy consumption shall include all energy used for comfort heating, comfort cooling, ventilation for the health and comfort of occupants, and service water heating.

3. Heat transfers within the same building to adjacent spaces that are not covered by the permit and that are independently provided with space conditioning may be considered to be zero. Heat transfers to spaces not yet provided with space conditioning may be modeled as separate unconditioned zones, or as outdoor conditions.

4. The total calculated annual energy consumption need not include energy from any nondepletable sources, regardless of the purpose of the energy consumed.

5. The U-factor of installed manufactured fenestration products shall be those certified by an approved independent certification organization in accordance with Section 116. The U-factor of field-fabricated fenestration products shall be those values from Section 116, Table 1-D, based on an approved method that determines the area weighted average U-factor for generic types of products.

6. Solar heat gain coefficients for interior shading devices used with fenestration products shall be 0.68 for vertical fenestration products and 1.0 for nonvertical fenestration products. No other solar heat gain coefficients shall be used for interior shading. The calculations for vertical fenestration products include the effects of draperies and insect screens without installation being verified at the time of final inspection.

**(f) Prescriptive Standards/Alternative Component Packages.** Buildings that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements of one of the alternative packages of components shown in Tables 1-Z1 through 1-Z16 for the appropriate climate zone shown in Figure 1-A. Installed components shall meet the following requirements:

## 1. Insulation.

- A. Ceiling, wall, slab floor perimeter and raised-floor insulation which has an R-value equal to or higher than that shown in Tables 1-Z1 through 1-Z16 shall be installed. The minimum opaque ceiling, wall (including heated basements and crawl spaces), and raised-floor R-values shown are for insulation installed between wood-framing members.

**ALTERNATIVE to Section 151 (f) 1 A:** The insulation requirements of Tables 1-Z1 through 1-Z16 may also be met by ceiling, wall or floor assemblies that meet equivalent minimum R-values that consider the effects of all elements of the assembly, using a calculation method approved by the executive director.

**EXCEPTION to Section 151 (f) 1 A:** Raised-floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Tables 1-Z1 through 1-Z16, a vapor barrier is placed over the entire floor of the crawl space, and the vents are fitted with automatically operated louvers.

- B. The minimum depth of concrete-slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.

**EXCEPTION to Section 151 (f) 1 B:** Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space, covered porches or covered patios.

2. **Radiant barrier.** A radiant barrier required in Tables 1-Z1 through 1-Z16 is any reflective material that has an emittance of 0.05 or less, tested according to ASTM C 1371-98 or ASTM E 408-71 (1996) e1, and that is certified to the Department of Consumer Affairs as required by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material. Installation criteria are contained in Section 4.24 of the Residential ACM Manual.

## 3. Glazing.

- A. Installed fenestration products shall have U-factors equal to or lower than those shown in Tables 1-Z1 through 1-Z16. The U-factor of installed fenestration products shall be determined pursuant to Section 151 (e) 5.

- B. Total glazing area shall not exceed the percentage of conditioned floor area specified in Tables 1-Z1 through 1-Z16.

4. **Shading.** Where Tables 1-Z1 through 1-Z16 require a solar heat gain coefficient of 0.40 or lower, the requirements shall be met by either:

- A. A fenestration product listed by the manufacturer to have the required solar heat gain coefficient; or
- B. An exterior operable louver or other exterior shading device that meets the required solar heat gain coefficient; or
- C. A combination of exterior shading device and fenestration product to achieve the same performance as achieved in Item A.
- D. For south-facing glazing by optimal overhangs installed so that the south-facing glazing is fully shaded at solar noon on August 21 and substantially exposed to direct sunlight at solar noon on December 21.

Except where the UBC requires emergency egress, exterior shading devices must be permanently attached to the outside of the structure with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps or ties).

5. **Thermal mass.** Thermal mass required for Package C in Tables 1-Z1 through 1-Z16 shall meet or exceed the minimum interior mass capacity specified in Table 1-U.

The mass requirements in Table 1-U may be met by calculating the combined interior mass capacity of the mass materials using Equation (1-P).

**EQUATION (1-P)—CALCULATION OF INTERIOR MASS CAPACITY**

$$IMC = [(A_1 \times UIMC_1) + (A_2 \times UIMC_2) \dots + (A_n \times UIMC_n)] \quad (1-P)$$

**WHERE:**

$A_n$  = area of mass material,  $n$ .

$UIMC_n$  = unit interior mass capacity of mass material,  $n$ .

**NOTE:** The commission's Residential Manual shall list the unit interior mass capacity (UIMC) of various mass materials.

**6. Heating system type.** Heating system types shall be installed as required in Tables 1-Z1 through 1-Z16. A gas-heating system is a natural or liquefied petroleum gas-heating system.

**7. Space heating and space cooling.** When refrigerant charge and airflow measurement or thermostatic expansion valves are shown as required by Tables 1-Z1 through 1-Z16, ducted split system central air conditioners and ducted split system heat pumps shall either have refrigerant charge and airflow measurement confirmed through field verification and diagnostic testing in accordance with procedures set forth in the ACM Manual or shall be equipped with a thermostatic expansion valve (TXV) with an access door or removable panel to verify installation of the TXV. All

TXVs shall be confirmed through field verification and diagnostic testing as specified in the ACM Manual. All space-heating and space-cooling systems must comply with minimum appliance efficiency standards as specified in Sections 110 through 112.

**8. Water-heating systems.** All water-heating systems must meet the water-heating budgets calculated from Equation (1-N).

**NOTE to Section 151 (f) 8:** Any gas-type domestic water heater of 50 gallons or less, which is certified as meeting the Appliance Efficiency Standards, and which meets tank insulation requirements of Section 150 (j) may be assumed to meet the water-heating budget.

**9. Setback thermostats.** All heating systems shall have an automatic thermostat with a clock mechanism or other setback mechanism approved by the executive director, which the building occupant can manually program to automatically set back the thermostat set points for at least two periods within 24 hours. The exception to Section 150 (i) shall not apply to any heating system installed in conjunction with the packages specified in Tables 1-Z1 through 1-Z16.

**10. Space-conditioning ducts.** All supply ducts shall either be in conditioned space or be insulated to a minimum installed level of R-4.2 and constructed to meet minimum mandatory requirements of Section 150 (m).

All duct systems shall be sealed, as confirmed through field verification and diagnostic testing, in accordance with procedures set forth in the ACM Manual.

**TABLE 1-U—INTERIOR MASS CAPACITY REQUIREMENTS FOR PACKAGE C**

FLOOR TYPE	MINIMUM INTERIOR MASS CAPACITY
slab floor	2.36 x ground floor area (ft <sup>2</sup> )
raised floor	0.18 x ground floor area (ft <sup>2</sup> )

TABLE 1-Z1—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 1

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA NR	R38 R21 (R4.76) NA R0 NR R19 <sup>3</sup> R8 NR
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 14%	0.65 16%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	NR NR NR NR	NR NR NR NR
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78%  6.8 6.6	No MIN  MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0  NR 9.7	MIN  NR MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.55 U-factor and a 90 percent AFUE furnace or a 7.6 HSPF heat pump can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z2—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 2

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA REQ	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R8 REQ
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 16%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z3—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 3

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R25 NA NA NA R7 R30 NA NR	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 NR
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 14%	0.75 20%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	NR NR NR NR	NR NR NR NR
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78%  6.8 6.6	No MIN  MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0  NR 9.7	MIN  NR MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z4—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 4

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE		
Insulation minimums <sup>2</sup>		
Ceiling	R38	R30
Wood-frame walls	R25	R13
“Heavy mass” walls	NA	(R2.44)
“Light mass” walls	NA	NA
Below-grade walls	NA	R0
Slab floor perimeter	R7	NR
Raised floor	R30	R19 <sup>3</sup>
Concrete raised floors	NA	R0
Radiant barrier	REQ	REQ
GLAZING		
Maximum U-factor <sup>3</sup>	0.40	0.75
Maximum total area	14%	20%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup>		
South-facing glazing	0.40	0.40
West-facing glazing	0.40	0.40
East-facing glazing	0.40	0.40
North-facing glazing	0.40	0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup>		
Electric-resistant allowed	Yes <sup>7</sup>	No
If gas, AFUE =	78%	MIN
If heat pump,		
split system HSPF <sup>8</sup> =	6.8	MIN
Single package system HSPF =	6.6	MIN
SPACE-COOLING SYSTEM		
If split system A/C, SEER =	10.0	MIN
Refrigerant charge and airflow measurement or		
thermostatic expansion valve	NR	NR
If single package A/C, SEER =	9.7	MIN
SPACE-CONDITIONING DUCTS		
Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE		
System must meet budget, see	Any <sup>9</sup>	Any
Section 151 (b) 1 and (f) 8		

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z5—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 5

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R25 NA NA NA R7 R30 NA NR	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 NR
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.75 16%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	NR NR NR NR	NR NR NR NR
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 NR 9.7	MIN NR MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z6—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 6

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R21 NA NA NA R7 R21 NA NR	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 NR
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.50 14%	0.75 20%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	NR NR NR NR	NR NR NR NR
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 NR 9.7	MIN NR MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.55 U-factor can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z7—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 7

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R21 NA NA NA R7 R21 NA NR	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 NR
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.50 14%	0.75 20%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78%  6.8 6.6	No MIN  MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0  NR 9.7	MIN  NR MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z8—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 8

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R21 NA NA NA R7 R21 NA REQ	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 REQ
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.50 14%	0.75 20%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z9—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 9

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R38 R21 NA NA NA R7 R21 NA REQ	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 REQ
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.50 14%	0.75 20%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z10—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 10

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R25 NA NA NA R7 R30 NA REQ	R30 R13 (R2.44) NA R0 NR R19 <sup>3</sup> R0 REQ
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 20%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z11—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 11

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA REQ	R38 R19 (R4.76) NA R0 NR R19 <sup>3</sup> R8 REQ
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 16%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z12—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 12

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA REQ	R38 R19 (R4.76) NA R0 NR R19 <sup>3</sup> R4 REQ
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 16%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and an 11.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z13—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 13

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA REQ	R38 R19 (R4.76) NA R0 NR R19 <sup>3</sup> R8 REQ
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 16%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.35 Solar Heat Gain Coefficient, and a 12.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z14—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 14

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA REQ	R38 R21 (R4.76) NA R0 NR R19 <sup>3</sup> R8 REQ
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.40 14%	0.65 16%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.30 Solar Heat Gain Coefficient, and a 12.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z15—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 15

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
BUILDING ENVELOPE Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R21 NA REQ	R38 R21 (R4.76) NA R0 NR R19 <sup>3</sup> R4 REQ
GLAZING Maximum U-factor <sup>3</sup> Maximum total area	0.40 16%	0.65 16%
SOLAR HEAT GAIN COEFFICIENT <sup>4</sup> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	0.40 0.40 0.40 0.40	0.40 0.40 0.40 0.40
THERMAL MASS <sup>5</sup>	REQ	NR
SPACE-HEATING SYSTEM <sup>6</sup> Electric-resistant allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
SPACE-COOLING SYSTEM If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 REQ 9.7	MIN REQ* MIN
SPACE-CONDITIONING DUCTS Duct sealing	REQ	REQ*
DOMESTIC WATER-HEATING TYPE System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.40 U-factor and maximum 0.30 Solar Heat Gain Coefficient, and a 13.0 SEER space-cooling system can be substituted for duct sealing and either refrigerant charge and airflow measurement or a thermostatic expansion valve. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes following Table 1-Z16.

TABLE 1-Z16—ALTERNATIVE COMPONENT PACKAGES FOR CLIMATE ZONE 16

COMPONENT	PACKAGE <sup>1</sup>	
	C <sup>1</sup>	D
<b>BUILDING ENVELOPE</b> Insulation minimums <sup>2</sup> Ceiling Wood-frame walls “Heavy mass” walls “Light mass” walls Below-grade walls Slab floor perimeter Raised floor Concrete raised floors Radiant barrier	R49 R29 NA NA NA R7 R30 NA NR	R38 R21 (R4.76) NA R13 R7 R19 <sup>3</sup> R8 NR
<b>GLAZING</b> Maximum U-factor <sup>3</sup> Maximum total area	0.40 14%	0.60 16%
<b>SOLAR HEAT GAIN COEFFICIENT<sup>4</sup></b> South-facing glazing West-facing glazing East-facing glazing North-facing glazing	NR NR NR NR	NR NR NR NR
<b>THERMAL MASS<sup>5</sup></b>	REQ	NR
<b>SPACE-HEATING SYSTEM<sup>6</sup></b> Electric-resistance allowed If gas, AFUE = If heat pump, split system HSPF <sup>8</sup> = Single package system HSPF =	Yes <sup>7</sup> 78% 6.8 6.6	No MIN MIN MIN
<b>SPACE-COOLING SYSTEM</b> If split system A/C, SEER = Refrigerant charge and airflow measurement or thermostatic expansion valve If single package A/C, SEER =	10.0 NR 9.7	MIN NR MIN
<b>SPACE-CONDITIONING DUCTS</b> Duct sealing	REQ	REQ*
<b>DOMESTIC WATER-HEATING TYPE</b> System must meet budget, see Section 151 (b) 1 and (f) 8	Any <sup>9</sup>	Any

\*As an alternative under Package D, glazing with a maximum 0.55 U-factor and a 90 percent AFUE furnace or a 7.6 HSPF heat pump can be substituted for duct sealing. All other requirements of Package D must be met.

Legend:

NR = Not required; NA = Not applicable; REQ = Required; MIN = Minimum

See notes on the following page.

#### NOTES TO THE LOW-RISE RESIDENTIAL PACKAGES IN TABLES 1-Z1 THROUGH 1-Z16

<sup>1</sup>Package C is the only package that allows electric-resistance space heating. Package C may be used only if the building is in an area (1) where natural gas is not currently available and (2) where extension of natural gas service is impractical, as determined by the natural gas utility. Package D allows more glazing area in some zones with moderately high insulation levels; slab edge insulation is required in Climate Zone 16.

<sup>2</sup>The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see Section 151 (f) 1 A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by 0.65. Any insulation installed on heavy or light-mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air. The exterior wall used to meet the R-value in parentheses cannot also be used to meet the thermal mass requirement.

<sup>3</sup>For glazing U-factor rating procedures and labeling requirements, see Section 116 (a) 2.

<sup>4</sup>Values specified are maximum allowable values. If the package specifies a solar heat gain coefficient, the builder shall meet the requirements of Section 151 (f) 4.

<sup>5</sup>If the package requires thermal mass, meet the requirements of Section 151 (f) 5.

<sup>6</sup>Automatic setback thermostats must be installed in conjunction with all space-heating systems in accordance with Section 151 (f) 9.

<sup>7</sup>Ducts in Package C shall be insulated to an installed value of at least R-8.

<sup>8</sup>HSPF means “heating seasonal performance factor.”

<sup>9</sup>Electric-resistance water heating is allowed as the main water heating source in Package C only if the water heater is located within the building envelope and a minimum of 25 percent of the energy for water heating is provided by a passive or active solar system or a wood stove boiler. The wood stove boiler credit is not allowed in Climate Zones 8, 10 and 15, nor in localities that do not allow wood stoves.

**NOTE:** Authority cited: Public Resources Code, Sections 25218 (e), 25402 and 25402.1. Reference: Public Resources Code, Section 25402.



## SUBCHAPTER 9

### LOW-RISE RESIDENTIAL BUILDINGS—ADDITIONS AND ALTERATIONS IN EXISTING LOW-RISE RESIDENTIAL BUILDINGS

#### SECTION 152 — ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS IN EXISTING BUILDINGS THAT WILL BE LOW-RISE RESIDENTIAL OCCUPANCIES

(a) **Additions.** Additions to existing residential buildings shall meet the requirements of Sections 111 through 118, Section 150, and either Section 152 (a) 1 or 2.

**EXCEPTION 1 to Section 152 (a):** Existing structures with R-11 framed walls showing compliance with Section 152 (a) 2 (Performance Approach) are exempt from Section 150 (c).

**EXCEPTION 2 to Section 152 (a):** Any dual-glazed greenhouse window and dual-glazed skylight installed in an addition complies with Section 151 (f) 3 A.

**EXCEPTION 3 to Section 152 (a):** If the addition will increase the total number of water heaters in the building, one of the following types of water heaters may be installed to comply with Section 152 (a) 1 or Section 152 (a) 2 A, and Section 152 (c):

1. A gas storage nonrecirculating water-heating system that does not exceed 50 gallons capacity; or
2. If no natural gas is connected to the building, an electric storage water heater that does not exceed 50 gallons capacity, has an energy factor not less than 0.90; or
3. A water-heater system determined by the executive director to use no more energy than the one specified in Item 1. above; or if no natural gas is connected to the building, a water-heating system determined by the executive director to use no more energy than the one specified in Item 2. above.

For prescriptive compliance with Section 152 (a) 1, the water-heating systems requirement in Section 151 (f) 8 shall not apply. For performance compliance for the addition alone, only the space-conditioning budgets of Section 151 (b) 2 shall be used; the water-heating budgets of Section 151 (b) 1 shall not apply.

The performance approach for the existing building and the addition in Section 152 (a) 2 B may be used to show compliance, regardless of the type of water heater installed.

**EXCEPTION 4 to Section 152 (a):** When heating and/or cooling will be extended to an addition from the existing system(s), the existing equipment need not comply with Title 24, Part 6. The heating system capacity must be adequate to meet the minimum requirements of UBC Section 310.11.

1. **Prescriptive approach.** Additions to existing buildings shall meet the following additional requirements:

- A. Additions up to 100 square feet shall not exceed 50 square feet of glazing, the glazing U-factor shall not exceed 0.75, and the glazing Solar Heat Gain Coefficient shall not exceed the value specified in Alternative Component Package D (Tables 1-Z1 through 1-Z16); or
- B. Additions less than 1,000 square feet shall meet all the requirements of Package D [Section 151 (f) and Tables 1-Z1 through 1-Z16], except that the addition's total glazing area limit is the maximum allowed in Package D plus the glazing area that was removed by the addition, and the wall insulation value need not exceed R-13.

**EXCEPTION to Section 152 (a) 1 B:** If an addition is less than 500 square feet, glazing may have a U-factor not to exceed 0.75 in lieu of any lower U-factor required by the package.

- C. Additions of 1,000 square feet or greater shall meet all the requirements of Package D [Section 151 (f) and Tables 1-Z1 through 1-Z16].

2. **Performance approach.** Performance calculations shall meet the requirements of Section 151 (a) through (e), pursuant to either Item A or B, below.

- A. The addition complies if the addition alone meets the combined water-heating and space-conditioning energy budgets.
- B. The addition complies if the energy efficiency of the existing building is improved such that the source energy consumption of the improved existing building and the addition is equal to or less than that of the unimproved existing building plus an addition that complies with the applicable energy budget.

(b) **Alterations.** Alterations to existing residential buildings or alterations in conjunction with a change in building occupancy to a low-rise residential occupancy shall meet either Item 1 or 2 below.

1. **Prescriptive approach.** The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110 through 118 and 150; and

- A. Alterations that add fenestration area to a building shall be limited to a maximum 0.75 U-factor and the Solar Heat Gain Coefficient for new fenestration products as specified in Alternative Component Package D (Tables 1-Z1 through 1-Z16).
- B. New space-conditioning systems or components shall:
  - i. Meet the requirements of Section 150 (h) and (i) and Section 151 (f) 7; and
  - ii. Be limited to natural gas, liquefied petroleum gas, or the existing fuel type unless it can be demonstrated that the source energy use of the new system is more efficient than the existing system.
- C. New service water heating systems or components shall:
  - i. Meet the requirements of Section 150; and
  - ii. Be limited to natural gas, liquefied petroleum gas, or the existing fuel type unless it can be demonstrated that the source energy use of the new system is more efficient than the existing system.

2. **Performance approach.**

- A. The altered components shall meet the applicable requirements of Sections 110 through 118 and 150; and
- B. Either:
  - i. The permitted space alone, which shall be a minimum of the square footage of the room in which the alteration is made, shall comply with Section 151; or
  - ii. The energy efficiency of the existing building shall be improved so that the building meets the energy budget in Section 151 that would apply if the existing building was unchanged and the permitted space alone complied with Item i. The permitted space shall be a minimum of the square footage of the room in which the alteration is made.

**EXCEPTION to Section 152 (b) 1 A:** Any dual-glazed greenhouse window and dual-glazed skylight installed as part of an alteration com-

plies with the U-factor requirements applicable to prescriptive alterations.

**NOTE:** Fenestration products repaired or replaced, not as part of an alteration, need not comply with the U-factor and Solar Heat Gain Coefficient requirements applicable to alterations.

**EXCEPTION to Section 152 (b) 2 B:** When the existing fuel type is electric, the existing or replacement equipment for heating, cooling and/or domestic water heating of the proposed building shall be assumed to be the same fuel type as the standard building.

(c) Electric-resistance water-heating or space-conditioning systems may be installed in or in conjunction with an addition only if the electric-resistance system meets the applicable energy budget(s) from Section 151 (b) pursuant to Section 152 (a) 2.

(d) Any addition or alteration may comply with the requirements of Title 24, Part 6 by meeting the requirements for new buildings for the building as a whole.

**NOTE:** Authority cited: Public Resources Code, Sections 25218 (e), 25402 and 25402.1. Reference: Public Resources Code, Section 25402.

## APPENDIX 1-A

### STANDARDS REFERENCED IN ENERGY EFFICIENCY REGULATIONS

#### STATE OF CALIFORNIA

Appliance Efficiency Regulations

Quality Standards for Insulating Material

Nonresidential Manual

Residential Manual

Various Directories for Certified Appliances

Available from: California Energy Commission  
Publications Office  
1516 Ninth Street, MS-13  
Sacramento, California 95814-5512  
(916) 654-5200

#### CONSUMER GUIDE TO CERTIFIED INSULATING MATERIALS

Available from: Consumer Affairs  
Standards for Insulating Material  
(916) 574-2060

#### INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

*Uniform Building Code*, 1997 Edition

*California Mechanical Code*, 1998 Edition

Available from: International Conference of  
Building Officials  
5360 Workman Mill Road  
Whittier, California 90601  
(562) 699-0541

#### AIR-CONDITIONING AND REFRIGERATION INSTITUTE

ARI 210/240-94 Standard for Unitary Air Conditioning and Air-Source Heat Pump Equipment

ARI 310/380-93 Standard for Packaged Terminal Air-Conditioners and Heat Pumps

ARI 320-98 Standard for Water-Source Heat Pumps

ARI 325-98 Standard for Ground Water-Source Heat Pumps

ARI 330-98 Ground Source Closed-Loop Heat Pumps

ARI 340/360-93 Standard for Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

ARI 365-94 Standard for Commercial and Industrial Unitary Air-Conditioning Condensing Units

ARI 460-2000 Standard for Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

ARI 550-92 Standard for Centrifugal or Rotary Screw Water-Chilling Packages

ARI 560-92 Standard for Absorption Water Chilling and Water Heating Packages

ARI 590-1992 Standard for Positive Displacement Compressor Water-Chilling Packages

Available from: Air-Conditioning and Refrigeration Institute  
4301 North Fairfax Drive, Suite 425  
Arlington, Virginia 22203  
(703) 524-8800

#### AIR CONDITIONING CONTRACTORS OF AMERICA

Manual J—Residential Load Calculation

Available from: Air Conditioning Contractors of America, Inc.  
1712 New Hampshire Avenue, NW  
Washington, DC 20009  
[www.acca.org/catalog/product.asp](http://www.acca.org/catalog/product.asp)  
(202) 483-9370  
Fax (202) 232-8545

#### AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (NATIONAL PUBLICATIONS)

Handbook and Product Directory

Equipment Volume, 2000 Edition

HVAC Applications Volume, Chapter 48, 1999 Edition

Fundamentals Volume, 1993 and 1997 Edition

#### STANDARDS

ANSI/ASHRAE 55-1992 Thermal Environment Conditions for Human Occupancy

ASHRAE 62-89 Standards for Natural and Mechanical Ventilation and Ventilation for Acceptable Indoor Air Quality

Available from: American Society of Heating, Refrigerating and Air-Conditioning Engineers  
1791 Tullie Circle N.E.  
Atlanta, Georgia 30329  
(404) 636-8400 or (800) 527-4723

#### AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (REGIONAL PUBLICATIONS)

Recommended Outdoor Design Temperatures for Northern California, 1977

Available from: ASHRAE  
Golden Gate Chapter  
370 Brannan Street  
San Francisco, California 94102  
(415) 495-4552

Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, Publication SPCDX, 1982

Available from: ASHRAE—Climatic Data  
Southern California Chapter  
Post Office Box 6306  
Alhambra, California 91802

**AMERICAN NATIONAL STANDARDS—Z21 SERIES**

- ANSI Z21.10.3-1998 Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h, Circulating and Instantaneous Water Heaters
- ANSI Z21.13-91 Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers
- ANSI Z21.47-1998 Standard for Gas-Fired Central Furnaces
- ANSI Z21.56-1998 Standards for Gas-Fired Swimming Pool Heaters
- ANSI Z83.8-1990 Standards for Gas Unit Heaters
- ANSI Z83.9-1990 Standards for Gas-Fired Duct Furnaces
- Available from: American Gas Association Laboratories  
8501 East Pleasant Valley Road  
Cleveland, Ohio 44131  
(216) 524-4990

**AMERICAN SOCIETY FOR TESTING AND MATERIALS**

- ASTM E 283-91 Standard Method of Test for Air Leakage Through Exterior Window, Curtain Walls, and Doors
- ASTM C 335-95 Steady State Heat Transfer of Horizontal Pipe Insulation
- ASTM C 177-85 Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
- ASTM C 518-91 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- ASTM C 731-93a Standard Test Method for Extrudability, After Package Aging, of Latex Sealants
- ASTM C 732-95 Standard Test Method for Aging Effects of Artificial Weathering on Latex Sealants
- ASTM C 271-94 Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
- ASTM C 1371-98 Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
- ASTM D 2202-93a Standard Test Method for Slump of Sealants
- ASTM E 96-95 Standard Test Methods for Water Vapor Transmission of Materials
- ASTM D 6083-97a Standard Specification for Liquid Applied Acrylic Coating Used in Roofing
- ASTM E 408-71 Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques  
(1996)e 1
- ASTM E 903-96 Standard Test Method for Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres
- ASTM E 1918-97 Standard Test Method for Measuring Solar Reflectance of Horizontal and Low Sloped Surfaces in the Field

Available from: American Society for Testing and Materials  
100 Barr Harbor Drive  
West Conshohocken, Pennsylvania 19428  
(610) 832-9500

**AMERICAN NATIONAL STANDARDS/UNDERWRITERS LABORATORIES**

- UL 181 Standard for Safety for Factory-made Air Ducts and Connectors
- UL 181A Standard for Safety for Closure Systems for Use with Rigid Air Ducts and Air Connectors
- UL 181B Standard for Safety for Closure Systems for Use with Flexible Air Ducts and Air Connectors
- ANSI/UL 726-90 Oil-Fired Boiler Assemblies
- ANSI/UL 727-86 Oil-Fired Control Furnaces
- UL 731-95 Oil-Fired Unit Heaters
- UL 795-94 Commercial-Industrial Gas-Heating Equipment
- Available from: Underwriters Laboratories  
333 Pfingsten Road  
Northbrook, Illinois 60062-2096  
(847) 272-8800

**AMERICAN SOCIETY OF MECHANICAL ENGINEERS**

- ANSI/ASME Steam Generating Units  
PTC4.1-64
- Available from: ANSI  
1430 Broadway  
New York, NY 10017  
(212) 868-1220

**ASSOCIATION OF HOME APPLIANCE MANUFACTURERS**

- ANSI/AHAM Room Air Conditioners  
RAC-1-87
- Available from: AHAM  
20 North Wacker Drive  
Chicago, IL 60606

**CODE OF FEDERAL REGULATIONS**

- 10 CFR, Part 430, Appendix N
- 21 CFR, Section 1002.12 (1996)
- 47 CFR, Parts 2 and 15 (1996)
- Available from: Department of Energy  
Washington, D.C. 20585

**COOLING TOWER INSTITUTE**

- CTI ATC-105 Acceptance Test Code for Water Cooling Towers  
(97)
- CTI STD-201 Certification Standard for Commercial Water Cooling Towers  
(1996)
- Available from: Cooling Tower Institute  
Post Office Box 73383  
Houston, Texas 77273  
(281) 583-4087

**HYDRONICS INSTITUTE**

HI Heating Boiler Standard 86, 6th Edition, June 1989

Available from: Hydronics Institute  
Berkeley Heights, New Jersey 07922  
(908) 464-8200

**ILLUMINATING ENGINEERING SOCIETY**

Office Lighting American National Standard Practice,  
ANSI/IES RP-1, 1993 IES Handbook, Applications Volume  
(1987 ed.)

Available from: IESNA  
120 Wall Street, 17th Floor  
New York, New York 10005  
(212) 248-5000  
Fax (212) 248-5017

**ISO**

ISO-13256-1 Water-Source Heat Pumps-Testing and  
Rating for Performance-Part 1:  
Water-to-Air and Brine-to-Air Heat Pumps

Available from: ISO  
1, rue de Varembe  
Case postale 56  
CH-1211  
Geneve 20, Switzerland

**ASSOCIATED AIR BALANCE COUNCIL**

AABC National Standards, 5th Edition, 1989

Available from: Associated Air Balance Council  
1518 K Street, NW, Suite 503

Washington, D.C. 20005

(202) 737-0202

NEBB Procedural Standards (1983)

**SHEET METAL AND AIR CONDITIONING  
CONTRACTORS NATIONAL ASSOCIATION**

HVAC Duct Construction Standards—Metal and Flexible,  
1995, 2nd Edition

Available from: Sheet Metal and Air Conditioning  
Contractors National Association  
1020 12th Street, Suite 101  
Sacramento, California 95814  
(916) 442-3807  
Fax (916) 442-6541

**NATIONAL FENESTRATION RATING COUNCIL (NFRC)**

NFRC 100 Procedure for Determining Fenestration  
Product U-factors (1997)

NFRC 100-SB Procedure for Determining Site-Built  
Fenestration U-factors and Thermal  
Performance Characteristics (2000)

NFRC 200 Procedure for Determining Fenestration  
Product Solar Heat Gain Coefficients at  
Normal Incidence (1995)

NFRC 400 Procedure for Determining Fenestration  
Product Air Leakage (1995)

Available from: National Fenestration Rating Council  
1300 Spring Street, Suite 500  
Silver Spring, Maryland 20910  
(301) 589-6372



## Chapter 6

### DUCT SYSTEMS

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#### SECTION 601 — SCOPE

Ducts and plenums which are portions of a heating, cooling, absorption or evaporative cooling system shall comply with the requirements of this chapter.

**601.1 Material.** Supply air, return air and outside air for heating, cooling or evaporative cooling systems shall be conducted through duct systems constructed of metal as set forth in Tables 6-A, 6-B and 6-C; metal ducts complying with UMC Standard 6-1 with prior approval; or factory-made air ducts complying with UL181. Ducts, plenums and fittings may be constructed of asbestos cement, concrete, clay or ceramics when installed in the ground or in a concrete slab, provided the joints are tightly sealed.

**601.1.1 Use of corridor as plenum.** Corridors shall not be used to convey air to or from rooms if the corridor is required to be of fire-resistive construction by Section 1005 of the Building Code.

**601.1.2 Use of concealed space as plenum.** Concealed building spaces or independent construction within buildings may be used as ducts or plenums.

**601.1.3 Gypsum products exposed in ducts.** When gypsum products are exposed in ducts or plenums, the air temperature shall be restricted to a range from 50°F to 125°F (10°C to 50°C) and moisture content shall be controlled so that the material is not adversely affected. For the purpose of this section, gypsum products shall not be exposed in ducts serving as supply from evaporative coolers, and in other air-handling systems regulated by this chapter when the temperature of the gypsum product will be below the dew point temperature.

See Chapter 8 for limitations on combustion products venting systems extending into or through ducts or plenums.

See Chapter 5 for limitations on environmental air systems exhaust ducts extending into or through ducts or plenums.

#### 601.2 Standards of Quality.

**601.2.1 General.** The standards listed below labeled "UMC Standards," "UBC Standards" and "UFC Standards" are also listed in Chapter 16, Part II, and are part of this code. The other standards listed below are recognized standards. (See Sections 1601, 1602 and 1603.)

**601.2.1.1 Standard for metal ducts.** UMC Standard 6-1, Standard for Metal Ducts.

**601.2.1.2 Standard for installation of factory-made air ducts.** UMC Standard 6-3, Standard for Installation of Factory-Made Air Ducts.

**601.2.1.3 Flame spread index.** UBC Standard 8-1, Test Method for Surface-burning Characteristics of Building Materials.

**601.2.1.4 Test method for fire and smoke characteristics of electrical cable and plastic sprinkler pipe.** UMC Standard 6-2, Test Method for Fire and Smoke Characteristics of Electrical Cable and Plastic Sprinkler Pipe.

**601.2.1.5 Galvanized sheet metals.** UMC Standard 2-2, Galvanized Sheet Metals.

**601.2.1.6 Testing procedures for local, auxiliary, remote station and proprietary protective signaling systems.** Chapter 7 of UFC Standard 10-2, Installation, Maintenance and Use of Fire-protection Signaling Systems.

#### 601.2.2 Recognized Standards.

**601.2.2.1 Leakage-rated dampers for use in smoke control systems.** Leakage Rated Dampers for Use in Smoke Control Systems, UL 555S, 1983.

**601.2.2.2 Fire dampers.** Fire Dampers, UL 555, 1990.

**601.2.2.3 Ceiling dampers.** Ceiling Dampers, UL 555C, 1992.

**601.2.2.4 Factory-made air ducts.** Factory-made Air Ducts and Connectors, UL 181, 1994.

**601.2.2.5 Closure systems for rigid factory-made air ducts.** Closure Systems for Use with Flexible Air Ducts and Air Connectors, UL 181B, 1995.

**601.3 Contamination Prevention.** Exhaust ducts under positive pressure and venting systems shall not extend into or pass through ducts or plenums. For appliance vents and chimneys, see Chapter 8.

**601.4 Combustibles within Ducts or Plenums.** Materials exposed within ducts or plenums shall have a flame-spread index of not more than 25 and a smoke-developed rating of not more than 50 when tested in accordance with the test for Surface Burning Characteristics of Building Materials, UBC Standard 8-1.

**EXCEPTIONS:** 1. Return-air and outside-air ducts, plenums or concealed spaces which serve a dwelling unit may be of combustible construction.

2. Air filters meeting the requirements of Section 403.

3. Water evaporation media in an evaporative cooler.

4. Charcoal filters when protected with an approved fire-suppression system.

5. Electrical wiring and optical fiber raceways in plenums shall comply with the Electrical Code. Flame propagation and smoke production characteristics of exposed electric cables and optical fiber raceways installed in concealed air space used as air plenums shall:

5.1 Exhibit a flame travel of 5 feet (1524 mm) or less, and

5.2 Produce smoke having an average optical density not greater than 0.15 and having a peak optical density of 0.5 or less when tested in accordance with UMC Standard 6-2.

5.3 Wiring meeting these requirements shall be listed and labeled as plenum cable as required by the Electrical Code.

5.4 Optical fiber raceways meeting these requirements shall be listed and labeled as plenum optical fiber raceways as required by the Electrical Code.

6. Nonmetallic fire sprinkler piping in plenums shall be listed and shall meet the following requirements:

6.1 Exhibit flame travel of 5 feet (1524 mm) or less, and

6.2 Produce smoke having an average optical density not greater than 0.15 and having a peak optical density of 0.5 or less when tested in accordance with UMC Standard 6-2.

**601.5 Factory-made Air Ducts.** Factory-made air ducts shall be approved for the use intended or shall conform to the requirements of UL 181. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other suitable identification indicating compliance with UL 181 and its class designation. These ducts shall be listed and shall be installed

in accordance with the terms of their listing, and the requirements of UL 181. Flexible air connectors are not permitted.

**601.6 Joints and Seams of Ducts.** Joints, seams and fittings of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing or other means.

**601.6.1 Residential round ducts.** Crimp joints for residential round ducts shall have a contact lap of at least  $1\frac{1}{2}$  inches (38 mm) and shall be mechanically fastened by means of at least three sheet-metal screws equally spaced around the joint, or an equivalent fastening method.

**601.6.2 Residential rectangular ducts.** Joints and seams for 0.016-inch (0.41 mm) (No. 28 gage) and 0.013-inch (0.33 mm) (No. 30 gage) residential rectangular ducts shall be as specified in Table 6-A for 0.019-inch (0.48 mm) (No. 26 gage) material.

**601.6.3 Rectangular ducts.** Joints and seams for rectangular duct systems shall be as specified in Table 6-A.

**601.6.4 Oval ducts.** Joints and seams for flat oval ducts and round ducts in other than single dwelling units shall be as specified in Table 6-B.

**601.6.5 Listed ducts.** Joints and seams and all reinforcements for factory-made air ducts and plenums shall meet with the conditions of prior approval in accordance with the installation instructions that shall accompany the product. Closure systems for rigid Class 1 air ducts and plenums shall conform to UL 181A, and flexible Class 1 air ducts shall conform to UL 181B.

**601.7 Metal.** Every duct, plenum or fitting of metal shall comply with Table 6-A or Table 6-B.

**EXCEPTIONS:** 1. Ducts, plenums and fittings for systems serving single dwelling units may comply with Table 6-C.

2. Duct systems complying with UL 181.

**601.8 Tinned Steel.** Existing tinned steel ducts may be used when cooling coils are added to a heating system, provided the first 10 feet (3048 mm) of the duct or plenum measured from the cooling coil discharge are constructed of metal of the gage thickness set forth in Table 6-A, 6-B or 6-C of this chapter or are of approved material and construction. Tinned ducts completely enclosed in inaccessible concealed areas need not be replaced. All accessible ducts shall be insulated to comply with Table 6-D of this chapter. For the purpose of this subsection, ducts shall be considered accessible if the access space is 30 inches (762 mm) or greater in height.

**601.9 Vibration Isolators.** Vibration isolators installed between mechanical equipment and metal ducts (or casings) shall be made of an approved material and shall not exceed 10 inches (254 mm) in length.

## SECTION 602 — QUALITY OF MATERIAL

Galvanized steel shall be of lock-forming quality with a minimum coating of 1.25 ounces per square foot ( $0.38 \text{ kg/m}^2$ ) of zinc conforming to the requirements of UMC Standard 2-2.

## SECTION 603 — INSTALLATION OF DUCTS

**603.1 Metal Ducts.** Ducts shall be securely fastened in place at each change of direction and as set forth in Table 6-E. Vertical rectangular ducts and vertical round ducts shall be supported as set forth in Table 6-E, Part I. Riser ducts shall be held in place by means of metal straps or angles and channels to secure the riser to the structure.

Metal ducts shall be installed with at least 4 inches (102 mm) of separation from earth. Metal ducts when installed in or under concrete slab shall be encased in at least 2 inches (51 mm) of concrete.

**603.1.1 Fire-resistive coatings.** Ducts shall be located so as to maintain the minimum required thickness of fire-resistive materials applied to structural members to provide the required fire-resistive rating.

**603.1.2 Rectangular duct supports.** Supports for rectangular ducts as set forth in Table 6-E when suspended from above shall be installed on two opposite sides of each duct and shall be riveted, bolted or metal screwed to each side of the duct at not more than the intervals specified.

**603.1.3 Horizontal round duct supports.** Horizontal round ducts 40 inches (1016 mm) or less in diameter when suspended from above shall be supported at intervals not more than as set forth in Table 6-E with one hanger installed to comply with the requirements listed below:

1. Ducts shall be equipped with tightfitting circular bands extending around the entire perimeter of the duct at each specified support interval.

2. Circular bands shall not be less than 1 inch (25 mm) wide nor less than equivalent to the gage of the duct material it supports.

**EXCEPTION:** Ducts 10 inches (254 mm) and less in diameter may be supported by No. 18 gage (10 mm) galvanized steel wire.

3. Each circular band shall be provided with a suitable means of connecting to the suspending support.

4. Ducts shall be braced and guyed to prevent lateral or horizontal swing.

**603.2 Factory-made Air Ducts.** Approved Class 0 or Class 1 factory-made air ducts may be installed in any occupancy covered by this code.

**603.2.1 Used as risers.** Factory-made air ducts shall not be used for vertical risers in air-duct systems serving more than two stories. Such ducts shall not penetrate construction where fire dampers are required.

**603.2.2 Protection.** Factory-made air ducts shall be installed with at least 4 inches (102 mm) of separation from earth, except when installed as a liner inside of concrete, tile or metal pipe; they shall be protected from physical damage.

**603.2.3 Temperature.** The temperature of the air to be conveyed in any of these classes of ducts shall be less than  $251^{\circ}\text{F}$  ( $122^{\circ}\text{C}$ ).

**603.3 Protection of Ducts.** Ducts installed in locations where they are exposed to mechanical damage by vehicles or from other causes shall be protected by approved barriers.

**603.4 Support of Ducts.** Installers shall furnish the manufacturer's field fabrication and installation instructions to building officials.

Support spacing and methods shall meet the requirements of UMC Standard 6-3.

Support materials shall be galvanized steel or meet the flame resistance and corrosion requirements of UL 181.

**603.5 Outside-air and Return-air Duct Size.** Outside-air and return-air ducts shall have the following minimum areas:

**603.5.1 Gravity furnaces.** The minimum unobstructed total area of the outside or return-air ducts or openings to a gravity-type warm-air furnace shall not be less than 7 square inches per 1,000 Btu/h ( $15.4 \text{ mm}^2/\text{W}$ ) approved output rating or as indicated by the conditions of listing of the furnace.

**603.5.2 Blower-type furnaces.** The minimum unobstructed total area of the outside or return-air ducts or openings to a blower-type warm-air furnace shall not be less than 2 square inches per 1,000 Btu/h (4.4 mm<sup>2</sup>/W) approved output rating or bonnet capacity of the furnace.

**603.5.3 Listing conditions.** The total area of the outside or return-air ducts or openings need not be larger than the minimum indicated by the conditions of listing of the furnace.

**603.5.4 Heat pumps.** The minimum unobstructed total area of the outside or return-air ducts or openings to a heat pump shall not be less than 6 square inches per 1,000 Btu/h (13.2 mm<sup>2</sup>/W) nominal output rating or as indicated by the conditions of listing of the heat pump.

**603.6 Dampers.** Volume dampers shall not be placed in the air inlet to a furnace in a manner which will reduce the required air to the furnace.

**603.7 Ducts for Blower-type Warm-air Furnace.** Except as provided in Section 404.1, air for every fuel-burning blower-type warm-air furnace shall be conducted into the blower housing from outside the furnace space by continuous airtight ducts.

#### 603.8 Supply-air Duct Size.

**603.8.1 Area.** The minimum unobstructed total area of the supply-air ducts from a blower-type warm-air furnace shall not be less than 2 square inches per 1,000 Btu/h (4.4 mm<sup>2</sup>/W) approved output rating of the furnace, and the minimum unobstructed total area of the supply-air ducts from a gravity-type warm-air furnace shall not be less than 7 square inches per 1,000 Btu/h (15.4 mm<sup>2</sup>/W) approved output rating or as specified by the conditions of listing of the furnace. The total area of the supply-air ducts need not exceed the area of the furnace outlet plenum collar.

For the purpose of this section, a volume damper, grille or register installed to control airflow shall not be considered an obstruction.

**603.8.2 Supply-air duct size heat pump.** The minimum unobstructed total area of the supply-air ducts from a heat pump shall not be less than 6 square inches per 1,000 Btu/h (13.2 mm<sup>2</sup>/W) nominal output rating or as indicated by the conditions of the listing of the heat pump.

**603.8.3 Surgical operating room.** Warm-air furnace duct openings serving a surgical operating room shall be at least 5 feet (1524 mm) above the floor.

### SECTION 604 — INSULATION OF DUCTS

**604.1 Amount of Insulation.** Supply- and return-air ducts and plenums of a heating or cooling system shall be insulated with not less than the amount of insulation set forth in Table 6-D, except for ducts and plenums used exclusively for evaporative cooling systems.

**604.2 Lining Materials.** Approved materials shall be installed within ducts and plenums for insulating, sound deadening or other purposes. Materials shall have a mold-, humidity- and erosion-resistant surface that meets the requirements of UL 181. Duct liners in systems operating with air velocities exceeding 2,000 feet per minute (10.2 m/s) shall be fastened with both adhesive and mechanical fasteners, and exposed edges shall have adequate treatment to withstand the operating velocity.

**604.3 External Insulation.** Insulation applied to the exterior surface of ducts located in buildings shall have a flame spread index of not more than 25 and a smoke-density index not exceeding

50 when tested as a composite installation, including insulation, facing materials, tapes and adhesives as normally applied.

**EXCEPTION:** Insulation having a flame-spread index not exceeding 50 and a smoke-density index not greater than 100 may be installed in dwellings or apartment houses where the duct system serves not more than one dwelling unit.

**604.4 Identification.** Factory-made air ducts and faced insulations intended for installation on the exterior of metal ducts shall be legibly printed with the name of the manufacturer, the thermal resistance (R) value at installed thickness, and the flame-spread index and smoke-developed index of the composite material.

### SECTION 605 — DAMPERS IN DUCT SYSTEMS

**605.1 Smoke Dampers.** Smoke dampers complying with recognized standards in Chapter 16, Part III, shall be installed in accordance with approved manufacturer's installation instructions when required by Chapters 7 and 9 of the Building Code. Smoke dampers shall be labeled by an approved agency.

**605.2 Fire Dampers.** Fire dampers complying with recognized standards in Chapter 16, Part III, shall be installed in accordance with approved manufacturer's installation instructions when required by Chapter 7 of the Building Code. Fire dampers shall have been tested for closure under airflow conditions and shall be labeled for both maximum airflow permitted and direction of flow. When more than one damper is installed at a point in a single air path, the entire airflow shall be assumed to be passing through the smallest damper area. Fire dampers shall be labeled by an approved agency. Only fire dampers labeled for use in dynamic systems shall be installed in heating, ventilation and air-conditioning systems which are intended to operate with fans "on" during a fire; see UBC Section 713.12.

Ductwork shall be connected to damper sleeves or assemblies in such a way that collapse of the ductwork will not dislodge the damper or impair its proper operation.

**605.3 Ceiling Dampers.** Ceiling dampers complying with recognized standards in Chapter 16, Part III, shall be installed in accordance with manufacturer's approved installation instructions in the fire-resistive ceiling element of floor-ceiling and roof-ceiling assemblies when required by Chapter 7 of the Building Code. Fire dampers not meeting the temperature limitation of ceiling dampers shall not be used as substitutes. Ceiling dampers shall be labeled by an approved agency.

**605.4 Multiple Arrangements.** When size requires the use of multiple dampers, the installation shall be framed in an approved manner to ensure that the dampers remain in place.

**605.5 Access and Identification.** Dampers shall be provided with an approved means of access, large enough to permit inspection and maintenance of the damper and its operating parts. The access shall not impair fire-resistive construction. Access shall not require the use of tools, keys or special knowledge. Access points shall be permanently identified on the exterior by a label with letters not less than 1/2 inch (13 mm) in height reading: SMOKE DAMPER or FIRE DAMPER. Access doors in ducts shall be tightfitting and suitable for the required duct construction.

**605.6 Freedom from Interference.** Dampers shall be installed in a manner to ensure positive closing or opening as required by function. Interior liners or insulation shall be held back from portions of a damper, its sleeve or an adjoining duct which would interfere with the damper's proper operation. Exterior materials shall be installed so as to avoid interference with the operation or maintenance of external operating devices needed for proper function.

**605.7 Temperature Classification of Operating Elements.** Fusible links, thermal sensors, and pneumatic or electric operators shall have a temperature rating or classification as required by the Building Code.

## SECTION 606 — VENTILATING CEILINGS

**606.1 General.** Perforated ceilings may be used for air supply within the limitations of this section. Exit corridors when required to be of fire-resistive construction by Section 1005.7 of the Building Code shall not have ventilating ceilings.

**606.2 Requirements.** Ventilating ceilings shall comply with the following provisions:

1. Suspended ventilating ceiling material shall have a Class I flame-spread index on both sides determined in accordance with Table 8-A of the Building Code. Suspended ventilating ceiling supports shall be of noncombustible materials.

2. Lighting fixtures recessed into the ventilating ceiling shall be of a type approved for that purpose.

## SECTION 607 — UNDER-FLOOR SPACE USED AS PLENUMS

An under-floor space may be used as a supply plenum, provided:

1. The use of under-floor space shall be limited to dwelling units not more than two stories in height. Except for the floor immediately above the under-floor plenum, supply ducts shall be provided extending from the plenum to registers on other floor levels.

2. Such spaces shall be cleaned of all loose combustible scrap material and shall be tightly and substantially enclosed.

3. The enclosing material of the under-floor space, including the sidewall insulation, shall not be more flammable than 1-inch (25 mm) (nominal) wood boards (flame-spread index of 200). Installation of foam plastics is regulated by the Building Code.

4. Access shall be through an opening in the floor and shall not be less than 24 inches by 24 inches (610 mm by 610 mm).

5. A furnace supplying warm air to under-floor space shall be equipped with an automatic control which will start the air-circulating fan when the air in the furnace bonnet reaches a temperature not higher than 150°F (65°C). Such control shall be one that cannot be set higher than 150°F (65°C).

6. A furnace supplying warm air to such space shall be equipped with an approved temperature limit control that will limit outlet air temperature to 200°F (93°C).

7. A noncombustible receptacle shall be placed below each floor opening into the air chamber, and such receptacle shall conform to the following:

7.1 The receptacle shall be securely suspended from the floor members and shall not be more than 18 inches (457 mm) below the floor opening.

7.2 The area of the receptacle shall extend 3 inches (76 mm) beyond the opening on all sides.

7.3 The perimeter of the receptacle shall have a vertical lip at least 1 inch (25 mm) high at the open sides if it is at the level of the bottom of the joists, or 3 inches (76 mm) high if the receptacle is suspended.

8. Floor registers shall be designed for easy removal in order to give access for cleaning the receptacles.

9. Exterior walls and interior stud partitions shall be fire blocked at the floor.

10. Each wall register shall be connected to the air chamber by a register box or boot.

11. A duct conforming with Section 601.1 shall extend from the furnace supply outlet at least 6 inches (152 mm) below combustible framing.

12. The entire ground surface of the under-floor space shall be covered with a vapor barrier having a minimum thickness of 4 mils (0.1 mm) and a flame-spread index of 200 or less.

13. Fuel-gas lines and plumbing waste cleanouts are not located within the space.

## SECTION 608 — SHUTOFF FOR SMOKE CONTROL

Air-moving systems supplying air in excess of 2,000 cubic feet per minute (940 L/s) to enclosed spaces within buildings shall be equipped with an automatic shutoff. Automatic shutoff shall be accomplished by interrupting the power source of the air-moving equipment upon detection of smoke in the main supply-air duct served by such equipment. Smoke detectors shall be labeled by an approved agency for air-duct installation and shall be installed in accordance with the manufacturer's installation instructions. Such devices shall be compatible with the operating velocities, pressures, temperatures and humidities of the system. Where fire detection or alarm systems are provided for the building, the smoke detectors required by this section shall be supervised by such systems.

**EXCEPTIONS:** 1. When the space supplied by the air-moving equipment is served by a total coverage smoke-detection system complying with UFC Standard 10-2, interconnection to such system may be used to accomplish the required shutoff.

2. Automatic shutoff is not required when all occupied rooms served by the air-handling equipment have direct exit to the exterior and the travel distance does not exceed 100 feet (30.4 m).

3. Automatic shutoff is not required for Group R, Division 3 and Group U Occupancies.

4. Automatic shutoff is not required for approved smoke-control systems or where analysis demonstrates shutoff would create a greater hazard, such as may be encountered in air-moving equipment supplying specialized portions of Group H Occupancies. Such equipment shall be required to have smoke detection with remote indication and manual shutoff capability at an approved location.

## SECTION 609 — PRODUCT-CONVEYING DUCT SYSTEMS

**609.1 Materials.** Materials used in product-conveying duct systems shall be suitable for the intended use and shall be of metal.

**EXCEPTIONS:** 1. Asbestos-cement, concrete, clay or ceramic materials may be used when it is shown that these materials will be equivalent to metal ducts installed in accordance with this chapter.

2. Ducts serving a Class 5 system may be constructed of approved nonmetallic material when the corrosive characteristics of the material being conveyed make a metal system unsuitable and when the mixture being conveyed is nonflammable.

Approved nonmetallic material shall be either a listed product having a flame-spread index of 25 or less and a smoke-developed rating of 50 or less on both inside and outside surfaces without evidence of continued progressive combustion, or shall have a flame-spread index of 25 or less and shall be installed with an automatic fire-sprinkler protection system inside the duct.

3. Ducts used in central vacuum-cleaning systems within a dwelling unit may be of PVC pipe. Penetrations of fire walls and floor-ceiling or roof-ceiling assemblies shall comply with Sections 709 and 710 of the Building Code. Copper or ferrous pipes or conduits extending from within the separation between a garage and dwelling unit to the central vacuuming unit may be used.

**609.1.1 Aluminum.** Aluminum ducts shall not be used in systems conveying flammable vapors, fumes or explosive dusts nor in Class 2, 3 or 4 systems. Galvanized steel and aluminum ducts shall not be used when the temperature of the material being conveyed exceeds 400°F (204°C).

Aluminum construction may be used in Class 1 product-conveying duct systems only. The thickness of aluminum ducts shall be at least two B.&S. gages thicker than the gages required for steel ducts set forth in Tables 5-B and 5-C.

**609.1.2 Linings.** Metal ducts used in Class 5 systems that are not resistant to the corrosiveness of the product shall be protected with appropriate corrosion-resistant material.

**609.2 Construction.** Ducts used for conveying products shall be of substantial airtight construction and shall not have openings other than those required for operation and maintenance of the system. Ducts constructed of steel shall comply with Table 5-B or 5-C.

**EXCEPTIONS:** 1. Class 1 product-conveying ducts that operate at less than 4 inches water column (995 Pa) negative pressure and convey noncorrosive, nonflammable and nonexplosive materials at temperatures not exceeding 250°F (121°C) may be constructed in accordance with Table 5-B, 6-A, 6-E or, with prior approval, UMC Standard 6-1.

2. Ducts used in central-vacuuming systems within a dwelling unit may be constructed of PVC pipe. Penetrations of fire-resistive walls and floor-ceiling or roof-ceiling assemblies shall comply with Sections 709 and 710 of the Building Code. Copper or ferrous pipes or conduit extending from within the separation between a garage and dwelling unit to the central vacuum unit may be used.

**609.2.1 Rectangular sections.** The use of rectangular ducts conveying particulates shall be subject to approval of the building official. The design of rectangular ducts shall consider the adhesiveness and buildup of products being conveyed within the duct.

**609.3 Fittings.** Fittings in Class 2, Class 3 and Class 4 product-conveying systems shall be at least two gages thicker than the thickness required for straight runs. Flexible metallic duct may be used for connecting ductwork to vibrating equipment. Duct systems subject to wide temperature fluctuations shall be provided with expansion joints.

Branches shall connect to main ducts at the large end of transitions at an angle not exceeding 45 degrees.

**609.4 Cleanouts.** Except for ducts used to convey noncorrosive vapors with no particulate, accessible cleanouts shall be provided at 10-foot (3048 mm) intervals and at changes in direction. Access openings shall also be provided for access to sprinklers and other equipment within the duct which requires servicing.

**609.5 Explosion Venting.** Ducts conveying explosive dusts shall have explosion vents, openings protected by antiflashback swing valves or rupture diaphragms. Openings to relieve explosive forces shall be located outside the building. When relief devices cannot provide sufficient pressure relief, ductwork shall be designed to withstand an internal pressure of not less than 100 pounds per square inch (689 kPa).

**609.6 Supports.** Spacing of supports for ducts shall not exceed 12 feet (3658 mm) for 8-inch (203 mm) ducts nor 20 feet (6096 mm) for larger ducts unless justified by the design. The design of supports shall assume that 50 percent of the duct is full of the particulate being conveyed.

**609.7 Fire Protection.** Sprinklers or other fire-protection devices shall be installed within ducts having a cross-sectional dimension exceeding 10 inches (254 mm) when the duct conveys flammable vapors or fumes. Sprinklers shall be installed at 12-foot (3658 mm) intervals in horizontal ducts and at changes in direction. In vertical runs, sprinklers shall be installed at the top and at alternate floor levels.

**609.8 Clearances.** Ducts conveying flammable or explosive vapors, fumes or dusts shall have a clearance from combustibles of not less than 18 inches (457 mm). This clearance may be reduced when the combustible construction is protected in accordance with Table 3-B.

**609.8.1 Elevated temperatures.** Ducts conveying products at temperatures exceeding 125°F (52°C) shall have a clearance to combustible materials not less than the following: 125°F to 250°F (52°C to 121°C)—1 inch (25 mm); 251°F to 600°F (122°C to 315°C)—8 inches (203 mm). For temperatures exceeding 600°F (315°C), the clearance shall not be less than required for chimneys in Table 8-D.

**609.9 Protection from Physical Damage.** Ducts installed in locations where they are subject to physical damage shall be protected by suitable guards.

**TABLE 6-A—CONSTRUCTION DETAILS FOR RECTANGULAR SHEET METAL DUCTS  
FOR STATIC AIR PRESSURES UP TO 2 INCHES WC**

For pressures in excess of 2-inch water column (498 Pa), duct wall thickness shall be two gages (for sheet gage equivalents see Appendix D) heavier than set forth in this table.

Duct specifications shown here are applicable when ducts larger than 18 inches (457 mm) are cross broken. Where cross breaking is not used, duct wall thickness shall be two gages (for sheet gage equivalents see Appendix D) heavier on ducts 19 inches through 60 inches (483 mm through 1524 mm) wide unless longitudinal standing seams are used.

MINIMUM METAL GAGES				
Steel—U.S. Standard, inches (gage)	Aluminum B.&S., inches (gage)	Copper Cold Rolled	Duct Dimension (inches)	Permissible Girth Joints and Longitudinal Seams
× 25.4 for mm		× 0.0026 for kg/m <sup>2</sup>	× 25.4 for mm	× 25.4 for mm
0.019 (26)	0.020 (24)	16 oz.	Up through 12	Drive slip, plain “S” slip, or 1” pocket lock
			13 through 18	Drive slip, plain “S” slip, or 1” pocket lock
0.024 (24)	0.025 (22)	24 oz.	19 through 30	Hemmed “S” slip, 1” bar slip, or 1” pocket lock on 5’ centers Hemmed “S” slip, 1” bar slip, or 1” pocket lock on 10’ centers with 1” × 1” × 1/8” angles on center line between Hemmed “S” slip, 1” bar slip, or 1” pocket lock on 10’ centers with cross break 1” standing seam on 5’ centers
0.030 (22)	0.032 (20)	32 oz.	31 through 42	1” bar slip, reinforced bar slip, or pocket lock, on 5’ centers 1” bar slip, reinforced bar slip, or pocket lock on 10’ centers with 1” × 1” × 1/8” angles on center line between 1” standing seam on 5’ centers Inside longitudinal standing seams with 1” × 1” × 1/8” angles on 5’ center on exterior
			43 through 54	1 1/2” bar slip, reinforced bar slip, or pocket lock on 4’ centers 1 1/2” bar slip, reinforced bar slip, or pocket lock on 8’ centers with 1 1/2” × 1 1/2” × 1/8” angles on center line between 1 1/2” bar slip, reinforced bar slip, or pocket lock on 4’ centers with cross break
			55 through 60	1 1/2” standing seam on 3’ centers Inside longitudinal standing seam with 1 1/2” × 1 1/2” × 1/8” angles on 4’ centers on exterior
0.036 (20)	0.040 (18)	36 oz.	61 through 84	Reinforced bar slip, angle slip, alternate bar slip, or angle reinforced pocket lock on 4’ centers using 1 1/2” × 1 1/2” × 1/8” reinforcing angles and with 1 1/2” × 1 1/2” × 1/8” angles on center line between Reinforced bar slip, angle slip, alternate bar slip, or angle reinforced pocket lock on 8’ centers using 1 1/2” × 1 1/2” × 1/8” reinforcing angles and with 1 1/2” × 1 1/2” × 1/8” angles 2’ on centers in between 1 1/2” angle reinforced standing seam on 2’ centers using 1 1/2” × 1 1/2” × 1/8” reinforcing angles Inside longitudinal standing seams with 1 1/2” × 1 1/2” × 1/8” angles on 2’ centers on exterior
0.047 (18)	0.050 (16)	48 oz.	85 through 96	Companion angles, angle slip, or angle reinforced pocket lock using 1 1/2” × 1 1/2” × 3/16” companion or reinforcing angles on 4’ centers with 1 1/2” × 1 1/2” × 3/16” angles on center line between Companion angles, angle slip, or angle reinforced pocket lock using 1 1/2” × 1 1/2” × 3/16” companion or reinforcing angles on 8’ centers with 1 1/2” × 1 1/2” × 3/16” angles on 2’ centers in between 1 1/2” angle reinforced standing seam on 2’ centers using 1 1/2” × 1 1/2” × 3/16” reinforcing angles Inside longitudinal standing seams with 1 1/2” × 1 1/2” × 3/16” angles on 2’ centers on exterior
			Over 96	Companion angles, angle slip, or angle reinforced pocket using 2” × 2” × 1/4” companion or reinforcing angles on 4’ centers with 2” × 2” × 1/4” angles on center line between Companion angles, angle slip, or angle reinforced pocket lock using 2” × 2” × 1/4” companion or reinforcing angles on 8’ centers with 2” × 2” × 1/4” angles 2’ on center line between 1 1/2” angle reinforced standing seam on 2’ centers using 2” × 2” × 1/4” reinforcing angles Inside longitudinal standing seams with 2” × 2” × 1/4” angles on 2’ centers on exterior

TABLE 6-B—CONSTRUCTION DETAILS FOR ROUND AND FLAT-OVAL DUCTS

DUCT DIAMETER MAXIMUM WIDTH (inches)	ALUMINUM B.&S. GAGE	STEEL—THICKNESS IN INCHES (STEEL—GALVANIZED SHEET GAGE)					GIRTH JOINTS <sup>1</sup>	
	Pressure ≤ 2" WC	Pressure ≤ 2" WC <sup>2</sup> (498 Pa)		Pressure > 2" ≤ 10" WC (498 Pa ≤ 2.5 kPa)			Pressure > 2" ≤ 10" WC	Minimum Girth Reinforcing, Maximum Spacing and Angle Size
		Round	Flat-Oval	Spiral Seam	Longitudinal Seam	Welded Fittings		
	× 25.4 for mm							
Up to 9	24	0.019 (26)	0.024 (24)	0.019 (26)	0.024 (24)	0.030 (22)	2" slip	None
Over 9 Up to 14	24	0.019 (26)	0.024 (24)	0.024 (24)	0.030 (22)	0.036 (20)	4" slip	None
Over 14 Up to 23	22	0.024 (24)	0.030 (22)	0.024 (24)	0.030 (22)	0.036 (20)	4" slip	None
Over 23 Up to 37	20	0.030 (22)	0.036 (20)	0.030 (22)	0.036 (20)	0.036 (20)	4" slip	None
Over 37 Up to 51	18	0.036 (20)	0.047 (18)	0.036 (20)	0.036 (20)	0.047 (18)	1¼" × 1¼" × ⅛" flange	1¼" × 1¼" × ⅛" on 72"
Over 51 Up to 61	16	0.047 (18)	0.058 (16)	X	0.047 (18)	0.047 (18)	1¼" × 1¼" × ⅛" flange	1¼" × 1¼" × ⅛" on 72"
Over 61 Up to 84	14	0.058 (16)	0.070 (14)	X	0.058 (16)	0.058 (16)	1½" × 1½" × ⅛" flange	1½" × 1½" × ⅛" on 48"

<sup>1</sup>For pressure ≤ 2 inches WC (498 Pa) any of the following joints are acceptable: butt slip, pipe slip, pipe lock, roll slip, snap slip, plenum lock and companion flange.

<sup>2</sup>Acceptable longitudinal seams for pressure ≤ 2 inches WC (498 Pa): Acme (grooved), snap lock, standing and spiral.

TABLE 6-C—THICKNESS OF METAL DUCTS AND PLENUMS USED FOR HEATING OR COOLING FOR A SINGLE DWELLING UNIT

SIZE AND SHAPE OF DUCT	GALVANIZED STEEL		APPROXIMATE ALUMINUM B.&S. GAGE
	Minimum Thickness (inches) × 25.4 for mm	Equivalent Galvanized Sheet Gage No.	
Round ducts and enclosed rectangular ducts 14" (356 mm) or less Over 14" (356 mm)	0.013 0.016	30 28	26 24
Exposed rectangular ducts 14" (356 mm) or less Over 14" (356 mm)	0.016 0.019	28 26	24 22

TABLE 6-D—INSULATION OF DUCTS

DUCT LOCATION	INSULATION TYPES MECHANICALLY COOLED	HEATING ZONE <sup>1</sup>	INSULATION TYPES HEATING ONLY
On roof on exterior of building	C, V <sup>2</sup> and W	I	A and W
		II	B and W
		III	C and W
Attics, garages and crawl spaces	A and V <sup>2</sup>	I	A
		II	A
		III	B
In walls, <sup>3</sup> within floor-ceiling spaces <sup>3</sup>	A and V <sup>2</sup>	I	A
		II	A
		III	B
Within the conditioned space or in basements; return ducts in air plenums	None required		None required
Cement slab or within ground	None required		None required

**NOTE:** Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

<sup>1</sup>Heating Degree Days:

Zone I below 4,500 D.D.  
Zone II 4,501 to 8,000 D.D.  
Zone III over 8,001 D.D.

<sup>2</sup>Vapor retarders shall be installed on supply ducts in spaces vented to the outside in geographic areas where the summer dew point temperature based on the 2<sup>1</sup>/<sub>2</sub> percent column of dry-bulb and mean coincident wet-bulb temperature exceeds 60°F (15.4°C).

<sup>3</sup>Insulation may be omitted on that portion of a duct which is located within a wall- or a floor-ceiling space where:

- 3.1 Both sides of the space are exposed to conditioned air.
  - 3.2 The space is not ventilated.
  - 3.3 The space is not used as a return plenum.
  - 3.4 The space is not exposed to unconditioned air.
- Ceilings which form plenums need not be insulated.

(Continued)

TABLE 6-D—INSULATION OF DUCTS—(Continued)

INSULATION TYPES<sup>4</sup>:

A—A material with an installed conductance of 0.48 [2.72 W/(m·K)] or the equivalent thermal resistance of 2.1 [0.367 (m·K)/W].

Examples of materials capable of meeting the above requirements:

1-inch (25 mm), 0.60 lb./cu. ft. (9.6 kg/m<sup>3</sup>) mineral fiber, rock, slag or glass blankets.

1/2-inch (13 mm), 1.5 to 3 lb./cu. ft. (24 to 48 kg/m<sup>3</sup>) mineral fiber blanket duct liner.

1/2-inch (13 mm), 3 to 10 lb./cu. ft. (48 to 160 kg/m<sup>3</sup>) mineral fiber board.

B—A material with an installed conductance of 0.24 [1.36 W/(m·K)] or the equivalent thermal resistance of 4.2 (0.735 m·K/w).

Examples of materials meeting the above requirements:

2-inch (51 mm), 0.60 lb./cu. ft. (9.6 kg/m<sup>3</sup>) mineral fiber blankets.

1-inch (25 mm), 1.5 to 3 lb./cu. ft. (24 to 48 kg/m<sup>3</sup>) mineral fiber blanket duct liner.

1-inch (25 mm), 3 to 10 lb./cu. ft. (48 to 160 kg/m<sup>3</sup>) mineral fiber board.

C—A material with an installed conductance of 0.16 [0.9 W/(m·K)] or the equivalent thermal resistance of 6.3 [1.1 (m·K)/W].

Examples of materials meeting the above requirements:

3-inch (76 mm), 0.60 lb./cu. ft. (9.6 kg/m<sup>3</sup>) mineral fiber blankets.

1 1/2-inch (38 mm), 1.5 to 3 lb./cu. ft. (24 to 48 kg/m<sup>3</sup>) mineral fiber blanket duct liner.

1 1/2-inch (38 mm), 3 to 10 lb./cu. ft. (48 to 160 kg/m<sup>3</sup>) mineral fiber board.

V—Vapor Retarders: Material with a perm rating not exceeding 0.5 perm [29 ng/(Pa·s·m<sup>2</sup>)]. All joints to be sealed.

W—Approved weatherproof barrier.

<sup>4</sup>The example of materials listed under each type is not meant to limit other available thickness and density combinations with the equivalent installed conductance or resistance based on the insulation only.

TABLE 6-E—DUCT SUPPORTS

## Part I—VERTICAL DUCTS

MAXIMUM SIDE OF RECTANGULAR DUCT	METAL STRAP OR ANGLE BRACKET	MAXIMUM DIAMETER OF ROUND DUCTS	STRAPS
× 25.4 for mm			
24"	1" × 1/8" (strap) <sup>1</sup>	10"	0.047" (No. 18 gage) galvanized steel 2" wide <sup>1</sup>
36"	1" × 1" × 1/8" angle <sup>1</sup>	20"	0.058" (No. 16 gage) galvanized steel 2" wide <sup>1</sup>
48"	1 1/8" × 1 1/8" × 1/8" angle <sup>1</sup>	40"	1/8" steel × 1 1/2" <sup>1</sup>
60"	1 1/2" × 1 1/2" × 1/8" angle <sup>1</sup>	60"	1/8" steel × 2" <sup>1</sup>
Over 60"	2" × 2" × 1/8" angle <sup>1</sup>	Over 60"	3/16" steel × 2" <sup>1</sup>

## Part II—HORIZONTAL DUCTS

18"	1" × 18 gage <sup>2</sup>	10"	Same gage as galvanized steel duct, 1" wide or (No. 18 gage galvanized steel wire) on 10' centers
30"	1" × 18 gage <sup>2</sup>		
48"	1" × 1/8" <sup>2</sup>	20"	Same gage as galvanized steel duct, 1" wide or (No. 8 gage galvanized steel wire) tied to 1" galvanized steel band around duct on 10' centers
60"	1" × 1/8" <sup>2</sup>	40"	
80"	1" × 1/8" <sup>2</sup>	60"	Same gage as galvanized steel duct, 1 1/2" wide on 6' centers
		Over 60"	Same gage as galvanized steel duct, 1 1/2" wide on 4' centers

## Part III—HORIZONTAL DUCTS—TRAPEZE-TYPE SUPPORTS

MAXIMUM DIAMETER OF ROUND DUCT OR SIDE OF RECTANGULAR DUCT	HORIZONTAL SUPPORT ANGLE <sup>3</sup>	HANGER
36"	1 1/2" × 1 1/2" × 1/8"	1/4" round rod or 1" × 1" × 1/8" angle
48"	2" × 2" × 1/8"	1/4" round rod or 1" × 1" × 1/8" angle
60"	2" × 2" × 1/8"	5/16" round rod or 1" × 1" × 1/8" angle
84"	2" × 2" × 1/8"	3/8" round rod or 1" × 1" × 1/8" angle

<sup>1</sup>Spaced vertically not more than 12 feet (3658 mm) on centers.

<sup>2</sup>Spaced horizontally not more than 10 feet (3048 mm) on centers.

<sup>3</sup>Spaced not more than 8 feet (2438 mm) on centers.

## UNIFORM MECHANICAL CODE STANDARD 6-3

### STANDARD FOR INSTALLATION OF FACTORY-MADE AIR DUCTS

Based on the 1989 Fibrous Glass Duct Construction Standards published  
by the Thermal Insulation Manufacturers Association and the Guidelines for Installing Flexible Ducts  
published by the Air Diffusion Council

See Section 603.2 of the *Uniform Mechanical Code*

#### SECTION 6.301 — SCOPE

These requirements are intended to supplement information contained in the manufacturer's installation instruction sheets included in each carton of material, which cover fabrication, closure methods, reinforcement and hanging of factory-made rigid and flexible air ducts complying with UL 181. The standard is divided into two parts: Part A covering rigid ducts and Part B covering flexible ducts.

#### Part A—Rigid Ducts

#### SECTION 6.302 — GENERAL

The use of these ducts is governed by Section 601.1, together with the restrictions contained in Section 603.2. For information regarding the fabrication of rectangular ducts from flat sheets of duct board, refer to the document upon which this standard is based, and the manufacturer's instruction sheet.

#### SECTION 6.303 — CLOSURE SYSTEMS

**6.303.1 General.** Closure systems are a vital element in the proper assembly of fibrous glass duct systems. They provide both

the structural connection and sealing of seams and joints for air tightness. Only listed closure systems identified in the manufacturer's installation instructions are suitable for use with rigid fibrous glass duct systems. Listed closures include:

1. Pressure-sensitive aluminum foil tapes.
2. Heat-activated aluminum foil/scrim tapes.
3. Mastic and glass fabric tape systems.

Listed closure systems may be used on listed duct board materials.

**6.303.2 Surface Preparation.** In order to obtain satisfactory adhesion and bonding, the surface on which closures will be applied must be free from dust, dirt, oil, grease, moisture and similar substances.

**6.303.3 Joint and Seam Preparation.** Longitudinal seams are fabricated with a shiplap joint which is closed with the use of outward-clinching staples at 2 inches (51 mm) on center, through the stapling flap of the jacketing material. Transverse joints between two duct sections are prepared by joining two duct sections, pulling the staple flap over the adjoining section and stapling as shown in Figure A6-3-1.

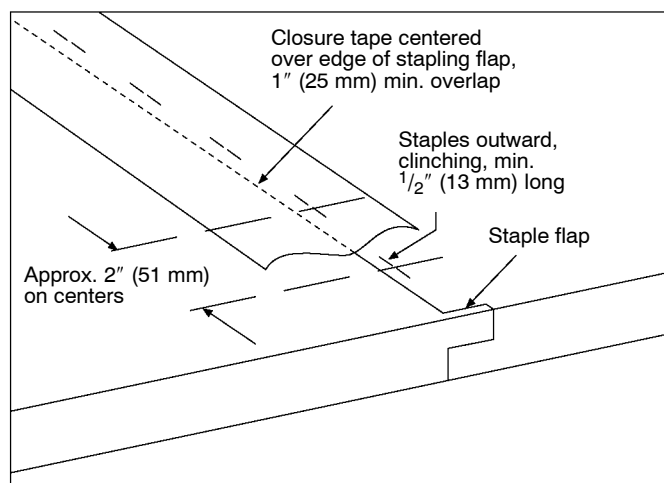


FIGURE A6-3-1—TAPE CLOSURE JOINT WITH STAPLE FLAP

When staple flaps are not present, crosstabs are used to hold seams and joints in position for reinforcing the closure system. Cross tabs, made from 8-inch (203 mm) minimum lengths of closure tape, are to be equally spaced on each side of the joint. Cross tabs are spaced on 12-inch (305 mm) (maximum) centers, with at least one cross tab per duct side (Figure A6-3-2). Cross tabs may be placed either under or over the closure tape.

**6.303.4 Application of Pressure-sensitive Aluminum Foil Tapes.** Use minimum 2½-inch-wide (64 mm) listed pressure-sensitive tape. Position the tape along the edge of the flap in a manner that will allow 1-inch-minimum (25 mm) overlap on adjacent surfaces.

If tape has been stored at temperatures less than 50°F (10°C), it should be conditioned prior to use by placement in a warm envi-

ronment in order to improve the initial tack.

If the duct board has been located in an atmosphere of less than 50°F (10°C), the surfaces to be taped must be preheated to ensure a satisfactory bond of the tape. Using any suitable heating iron with the plate temperature set at 400°F (± 25°F) (204°C ± 14°C) pre-heat the area to be taped. Quickly position the tape on the pre-heated area and press in place. Pass the iron two or three times over the taped area using a rapid “ironing” motion (see Figure A6-3-5).

Rub tape firmly with a plastic squeegee (Figure A6-3-3) until the facing reinforcement shows through the tape.

When operating pressure is less than 1 inch w.g. (249 Pa) (positive pressure), and sheet metal surfaces are cleaned in accordance with tape manufacturer’s instructions, pressure-sensitive tape may be used to seal fibrous glass duct to sheet metal.

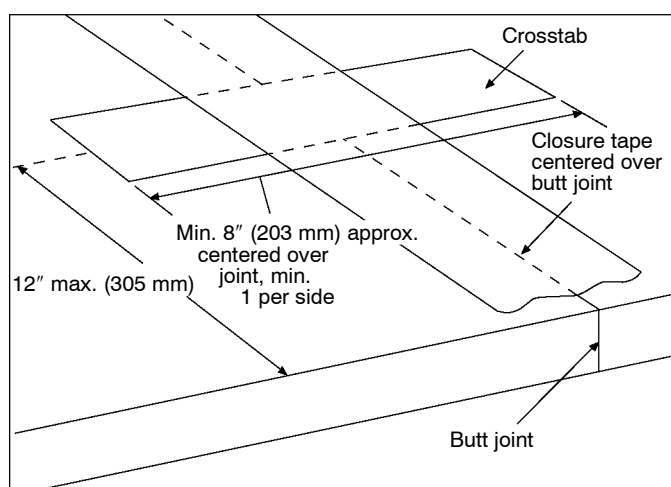


FIGURE A6-3-2—TAPE CLOSURE JOINT WITHOUT STAPLE FLAP

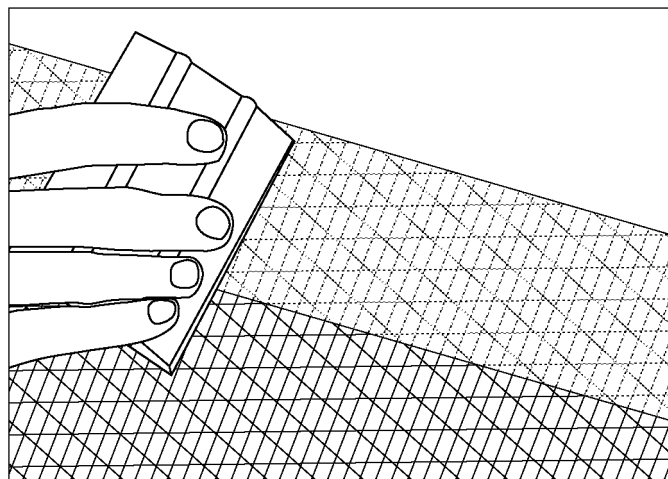


FIGURE A6-3-3—PRESSURE-SENSITIVE TAPE

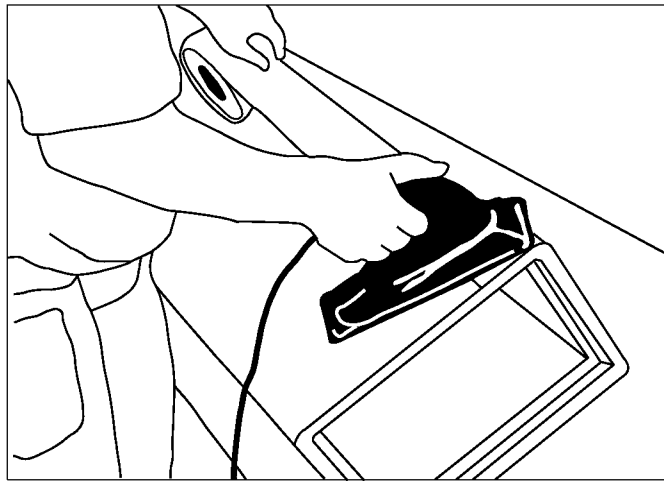


FIGURE A6-3-4—HEAT-ACTIVATED TAPE

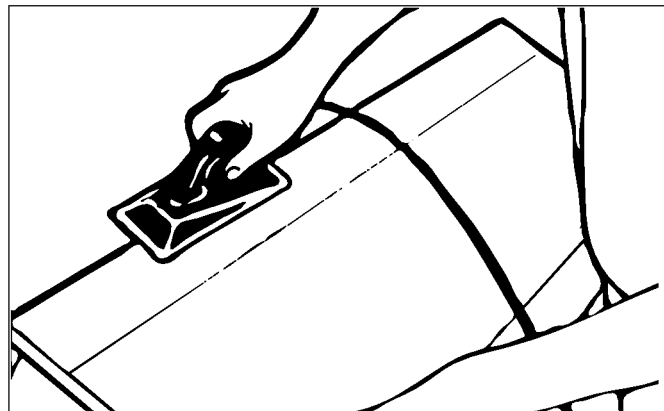


FIGURE A6-3-5—HOT IRON, SECOND PASS

**6.303.5 Application of Heat-activated Tapes.** Position the 2½-inch (64 mm) (minimum) tape along the edge of the flap in a manner that will allow a 1-inch-minimum (25 mm) overlap on adjacent surfaces. Using a suitable heating iron with a plate temperature between 550°F and 600°F (287°C and 315°C), pass the iron along the tape seam with sufficient pressure and dwell time to activate the adhesive (see Figure A6-3-4). A satisfactory bond has been achieved when the heat indicator dots have darkened.

Use a second pass of the iron to complete the bond by applying pressure to the front edge of the iron in a smearing action (see Figure A6-3-5).

Allow all joints and seams to cool below 150°F (65°C) before any stress is applied. Avoid puncturing the tape at staple locations with excessive pressure from the iron.

**6.303.6 Application of Glass-fab and Mastic Tape Systems.** Apply a thin coat of mastic approximately 3½ inches

(89 mm) wide over the center of the joint seam. Firmly press the 3-inch-wide (76 mm) glass fabric into the mastic (see Figure A6-3-6).

Apply a second coat of mastic over the glass fabric, filling the scrim pattern as indicated in Figure A6-3-7.

Follow the manufacturer's label instructions on application rate, safety precautions, ventilation requirements, shelf life limitations and minimum setup time required before stress can be applied to the joint or seam.

When connecting fibrous glass duct systems to sheet metal, as in connections to flanges or central air equipment, fasteners such as sheet metal screws and washers must be used to carry the mechanical load. Glass fabric and mastic can then be applied to seal the connections at these points. Usually, two widths of glass fabric will be required.

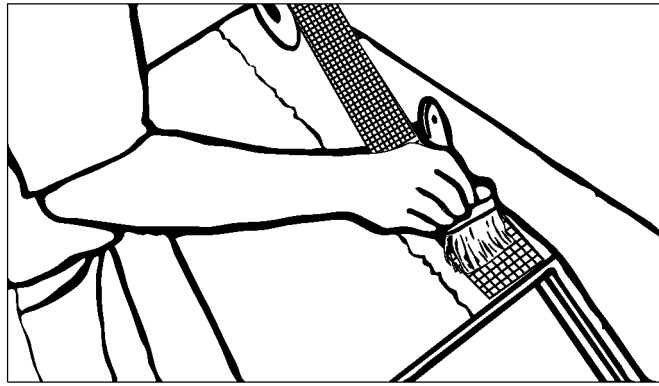


FIGURE A6-3-6—GLASS FABRIC INTO MASTIC

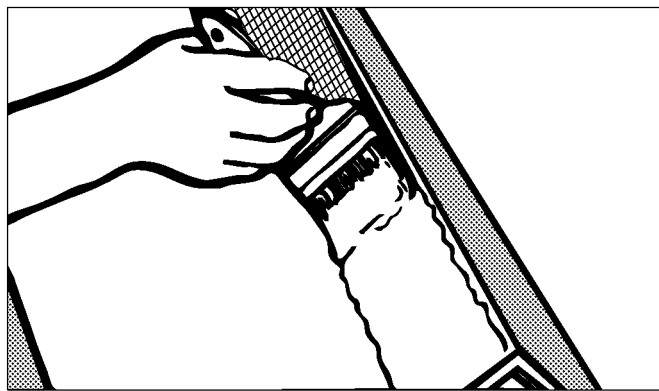


FIGURE A6-3-7—SECOND COAT OF MASTIC

## SECTION 6.304 — REINFORCEMENT

**6.304.1 General.** Reinforcement is used to limit the deflection of the duct surface caused by internal static pressure loading. The maximum dimension of unreinforced ducts, which is a function of the system operating pressure, is shown on the manufacturer's label, affixed to each piece of duct board.

Duct systems made from Types 475 and 800 fibrous glass duct board may use one or more of the following reinforcement methods:

1. Tie rod reinforcement.
2. Channel reinforcement.

The reinforcement schedules contained in Tables A6-3-A, A6-3-B and A6-3-D are suitable for 0 inch to 2 inch w.g. (0 Pa to 498 Pa) duct systems.

While some duct dimensions may not require any reinforcement in straight sections, certain fittings of the same dimension may require reinforcement. This requirement is noted wherever applicable in this standard and in Table A6-3-D. Fitting reinforcement is accomplished by the use of tie rods wherever possible, and with channel reinforcement applied where tie rods cannot be used.

### 6.304.2 Tie-rod Reinforcement—Positive Pressure.

**6.304.2.1 Tie rods.** Tie rods consist of straight lengths of 12 gage (2 mm) galvanized steel wire with flat steel volcano-type washers and any of three approved termination devices (see Figure A6-3-8). The 2½-inch (64 mm) square shall be installed so turned edges face away from the duct board facing.

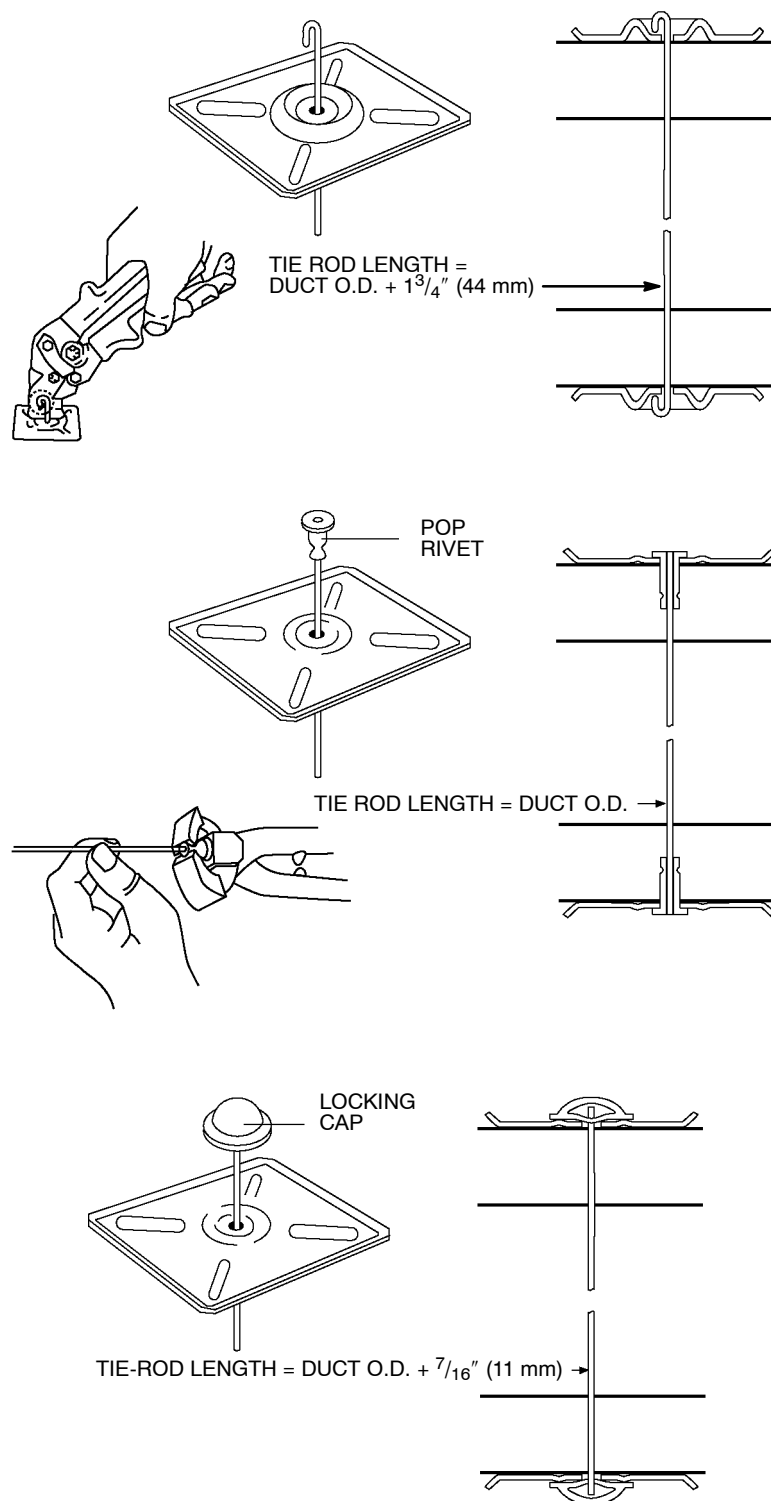


FIGURE A6-3-8—TERMINATIONS: FASLOOP; POP RIVET SLEEVE; LOCKING CAP

**6.304.2.2 Location.** In relation to transverse joints, the tie rods are spaced 4 inches (102 mm) from the end of the female joint, as shown in Figure A6-3-9.

When butt joints are used instead of shiplap joints, tie rods are placed in rows located at 3 inches (76 mm) on either side of the joint.

Alternate: A single tie-rod reinforcement may be used if the butt

joint is glued with an adhesive system documented by the duct board manufacturer.

**6.304.2.3 Spacing.** Tie rods are placed in rows of two to five rods, across the face of the duct, with row spaces varying from 16 inches to 48 inches (406 mm to 1219 mm) depending on duct size and operating pressure.

The spacing of tie rods is shown in Table A6-3-A.

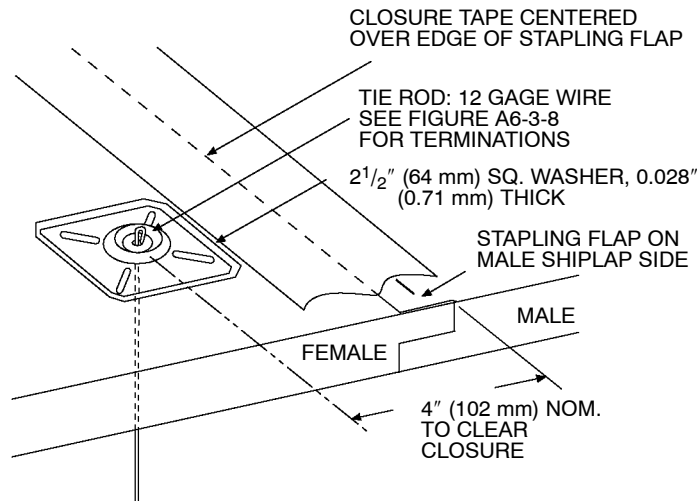
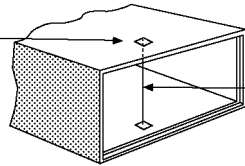


FIGURE A6-3-9—TIE-ROD PLACEMENT

TABLE A6-3-A—TIE-ROD SYSTEM REINFORCEMENT SCHEDULE

WASHER, 2 1/2" (64 mm)  
SQUARE x 0.028" (0.71 mm)  
THICK WITH TURNED  
EDGES AWAY FROM  
FACING, VOLCANO TYPE,  
HOLE IN CENTER



TIE ROD: 12 GAGE  
STRAIGHT GALVANIZED  
STEEL WIRE. SEE FIGURE  
A6-3-8 FOR APPROVED  
WIRE TERMINATIONS

TIE-ROD SYSTEM REINFORCEMENT SCHEDULE (Positive Pressure Only)								
Positive Static Pressure (× 249 for Pa)	Maximum inside Duct Dimension, Inches (× 25.4 for mm)	Type 475 Board			Type 800 Board			
		No. Rods across Dimension	Maximum Longitudinal Spacing (× 25.4 for mm)	No. Rods Per 4-ft. Section (1219 mm)	No. Rods across Dimension	Maximum Longitudinal Spacing (× 25.4 for mm)	No. Rods Per 4-ft. Section (1219 mm)	
0 to 1/2" w.g.	0-36	*			*			
	37-42	2	24"	4	2	48"	2	
	43-48			6	3		24"	3
	49-60	8				4		6
	61-64	10				5		8
	65-80				10			
	81-96							
Over 1/2" to 1" w.g.	0-24	*			*			
	25-30	1	24"	2	1	48"	1	
	31-32			4	2	24"	2	
	33-36	6					3	4
	37-48	8					4	6
	49-64	10		5	8			
	65-80				10			
	81-96							
Over 1" to 2" w.g.	0-15	*			*			
	16-18	1	24"	2	*			
	19-24		16"	3	1	24"	1	
	25-32			6	2		2	
	33-48	9		3	4			
	49-60	12		4	16"	6		
	61-64	15		5		9		
	65-80					12		
	81-96				15			

\*Straight ducts of these dimensions do not require reinforcement. However, some fittings of these dimensions may require reinforcement.

## NOTES:

1. Tie rods and washers must be no more than 16 inches (406 mm) on centers across duct dimension.
2. Ducts of 48-inch (1219 mm) width and over require use of antisag devices.
3. For duct dimensions over 96 inches (2438 mm), maintain tie rod spacing on 16-inch (406 mm) centers across the duct dimension following longitudinal spacing for the design pressure.

When the sides of the duct exceed the dimensions which require reinforcement (see Table A6-3-A), horizontal tie rods are also installed per the schedule.

**6.304.2.4 Typical tie-rod reinforcement examples, positive pressure ducts.** See Section 6.304.2.2 for placement of tie rods and sag supports in relation to joints. Sag support is required in ducts 48 inches (1219 mm) and greater in width.

The number of tie rods across the duct width shall be as required in the schedule contained in Table A6-3-A.

The longitudinal spacing of the rows of tie rods is based on the schedule in Table A6-3-A. This spacing will vary from 48 inches (1219 mm) on center to as close as 16 inches (406 mm) on center.

**6.304.2.5 Sag control—Tie-rod reinforcement shiplapped joints.** Top panels of fibrous glass duct sections or fittings 48 inches (1219 mm) wide or greater may sag due to the weight of the duct board when the system is not pressurized. To control this condition, sag supports must be provided. Figure A6-3-11A shows a typical installation.

Sag supports do not replace tie-rod assemblies as called for in the reinforcement schedule, but must be installed in addition to them. Hangers must be located within 12 inches (305 mm) of the sag supports.

For easier mating of fittings and duct sections during installation, a 1/2-inch-diameter (13 mm) steel conduit and washers may be added to an existing tie-rod assembly at the female shiplap end.

When ducts are fabricated with butt joints, sag supports must be installed on both sides of the joint. A hanger must be installed within 12 inches (305 mm) of the sag support.

### 6.304.3 Channel Reinforcement.

**6.304.3.1 General.** Another reinforcement system, for use in either positive or negative pressure duct systems, consists of formed sheet metal channels wrapped around the perimeter of the duct.

When channels must be attached to the duct, for sag control or negative-pressure reinforcement, No. 10 plated sheet metal screws and 2 1/2-inch (64 mm) square, 0.020-inch (0.5 mm) (minimum) thick sheet metal washers are used. These must have turned edges to prevent cutting into the duct board. In positive-pressure applications, wraparound channels need not be attached to the duct board except when required for sag control.

Table A6-3-B gives longitudinal spacing, sheet metal gage and channel height dimensions of reinforcement, depending on the duct board type, maximum inside dimensions and static pressure. This is a minimum reinforcement schedule applying to straight sections. This schedule will also apply to fittings, but a simplified schedule may also be used (see Table A6-3-C).

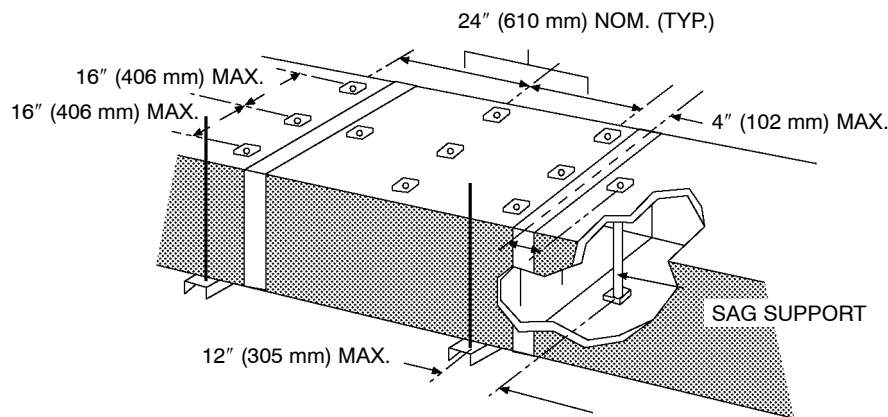


FIGURE A6-3-10—TIE-ROD REINFORCEMENT ROWS ON 24-INCH (610 mm) CENTERS, 48-INCH (1219 mm) DUCT SECTION

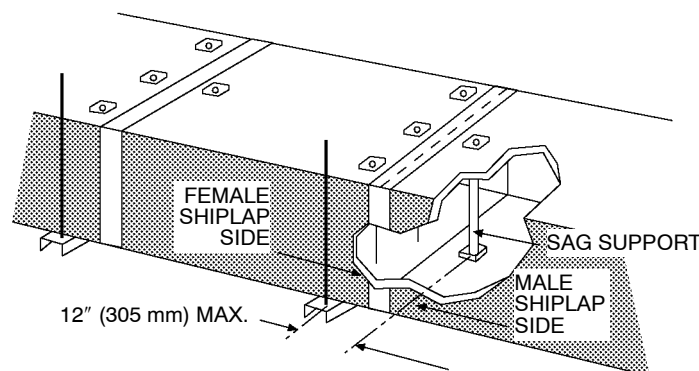


FIGURE A6-3-11A—SAG CONTROL—TIE-ROD REINFORCEMENT

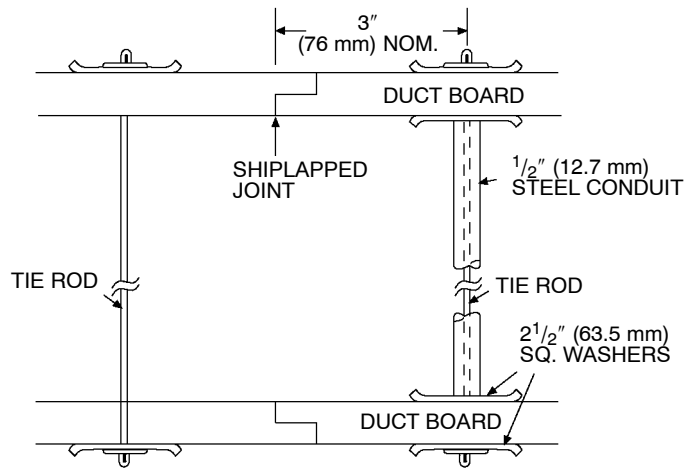


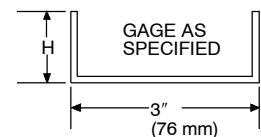
FIGURE A6-3-11B—SAG CONTROL DETAIL

TABLE A6-3-B—CHANNEL SYSTEM REINFORCEMENT SCHEDULE

CHANNEL SYSTEM REINFORCEMENT SCHEDULE								
Static Pressure		Maximum inside Duct Dimension (I.D.), In.	Type 475 Board			Type 800 Board		
			Maximum Longitudinal Spacing	Channel Gage (See Appendix D for sheet gage equivalency)	H Dimension (See Below)	Maximum Longitudinal Spacing	Channel Gage (See Appendix D for sheet gage equivalency)	H Dimension (See Below)
× 249 for Pa		× 25.4 for mm		× 25.4 for mm		× 25.4 for mm		× 25.4 for mm
0 to 1/2" w.g.	Negative	0-30	*			*		
	Positive	31-36	24"	22	1"	48"	22	1"
0 to 1/2" w.g. positive or negative		0-36	*			*		
		37-42	24"	22	1"	48"	22	1"
		43-48						1 1/2"
		49-60						1"
		61-72			24"	1"		
		73-84						
	85-96	1 1/4"						
Over 1/2" to 1" w.g. positive or negative		0-24	*			*		
		25-30	24"	22	1"	48"	22	1"
		31-36						
		37-42						
		43-48						
		49-60						
		61-72		18	1 1/4"			
		73-84						
	85-96							
Over 1" to 2" w.g. positive or negative		0-15	*			*		
		16-18	24"	22	1"	*		
		19-24						
		25-36	16"			18	1 1/4"	
		37-48						
		49-60						
		61-72						
		73-84	18	1 1/4"				
		85-96			16"	18	1"	
		1 1/2"						

\*Straight ducts of these dimensions do not require reinforcement; however, some fittings of these dimensions may require reinforcement.

**NOTE:** Ducts of 48-inch (1219 mm) maximum width and over require use of antisag devices.



**6.304.3.2 Channels.** Channels must be fabricated from galvanized sheet metal of the gage shown in Table A6-3-B.

Channels are 3 inches (76 mm) wide, with a height ( $H$ ) as shown in Table A6-3-B.

Each reinforcement may be fabricated from a continuous length of channel having three 90-degree bends and a fourth 90-degree corner which is fastened with bolts, screws, rivets, spot welds or staples. Reinforcements may also be fabricated with two, three or four securely fastened corners.

**6.304.3.3 Location of channels.** Channels are normally offset 4 inches (102 mm) from the end of the duct section to facilitate installation of sag supports and the closure system.

Where wraparound channels without sag support are used, the channel is slipped over the closure tape after the tape is applied, and centered over the female shi lap end for maximum support.

**6.304.3.4 Sag support and typical channel reinforcement.** When the duct is 48 inches (1219 mm) wide or greater,

channels are secured to the top for sag support with No. 10 plated sheet metal screws and 2 $\frac{1}{2}$ -inch (64 mm) square washers (see Detail A). The number of channels along the duct shall be in accordance with Table A6-3-B.

#### 6.304.4 Negative-pressure Channel Reinforcement.

**6.304.4.1 Locating reinforcing channels.** In negative-pressure applications such as return-air ducts, the channel reinforcement is applied over the male shi lap. Special clips are installed inside the duct (see Figure A6-3-13), which will support both the male and female sides of the duct joint. The clips are fastened in place with two sheet metal screws.

**6.304.4.2 Clips.** Clips are formed from 20 gage (0.036 inch) (0.91 mm) galvanized steel, with turned edges as shown in Detail B.

Clips are spaced not more than 16 inches (406 mm) apart and not more than 16 inches (406 mm) from the sides of a duct. The number of clips required is shown in Table A6-3-C.

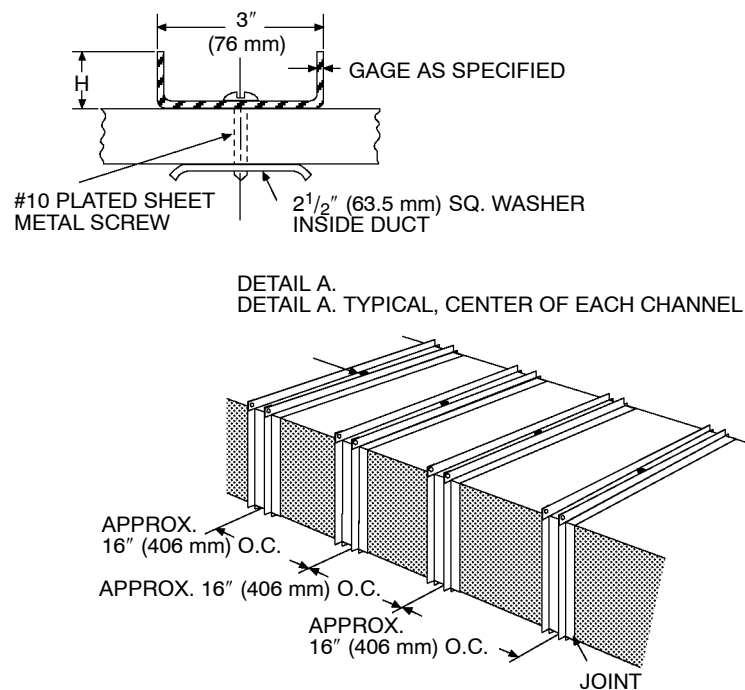


FIGURE A6-3-12—16-INCH (406 mm) CENTERS, 48-INCH (1219 mm) DUCT SECTIONS

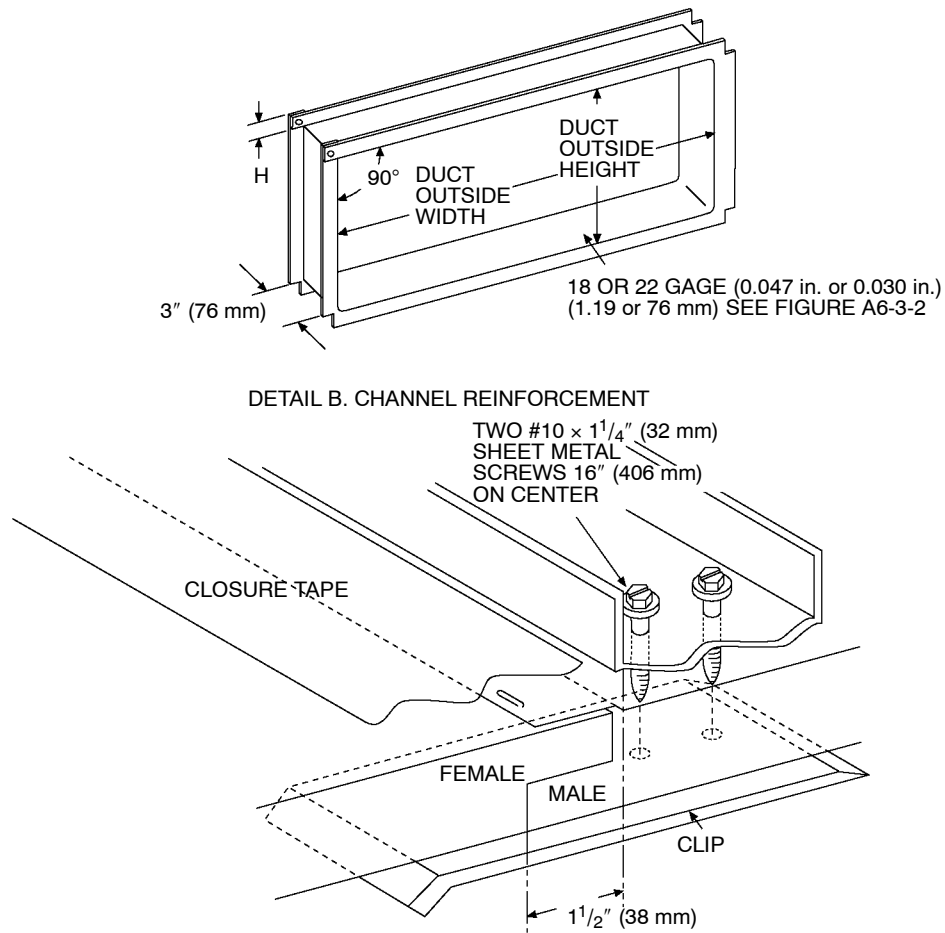


FIGURE A6-3-13—CHANNEL REINFORCEMENT FOR NEGATIVE-PRESSURE SYSTEMS

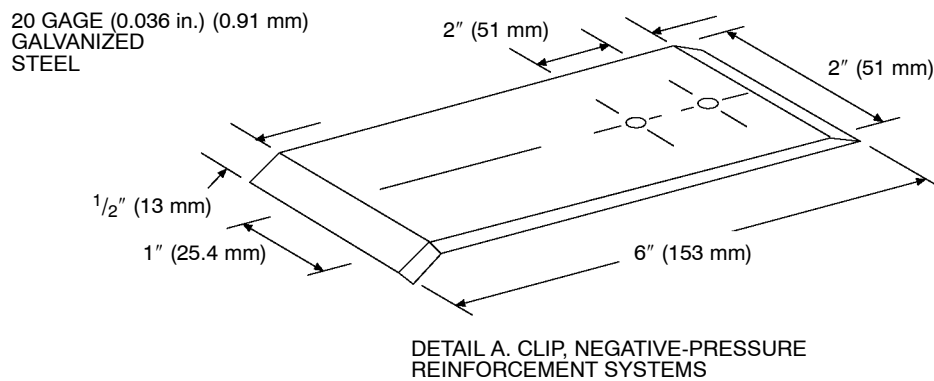


FIGURE A6-3-14—DETAIL B—CLIP, NEGATIVE-PRESSURE SYSTEMS

TABLE A6-3-C—NEGATIVE-PRESSURE FASTENERS

FASTENER REQUIREMENTS, NEGATIVE PRESSURE	
Transverse Dimension (inches)	Minimum Number of Clips or Washers per Reinforcing Member
× 25.4 mm	
16-32	1
33-48	2
49-64	3
65-80	4
81-96	5

**NOTE:** The foregoing arrangements are important and, if not followed closely, may result in system failure.

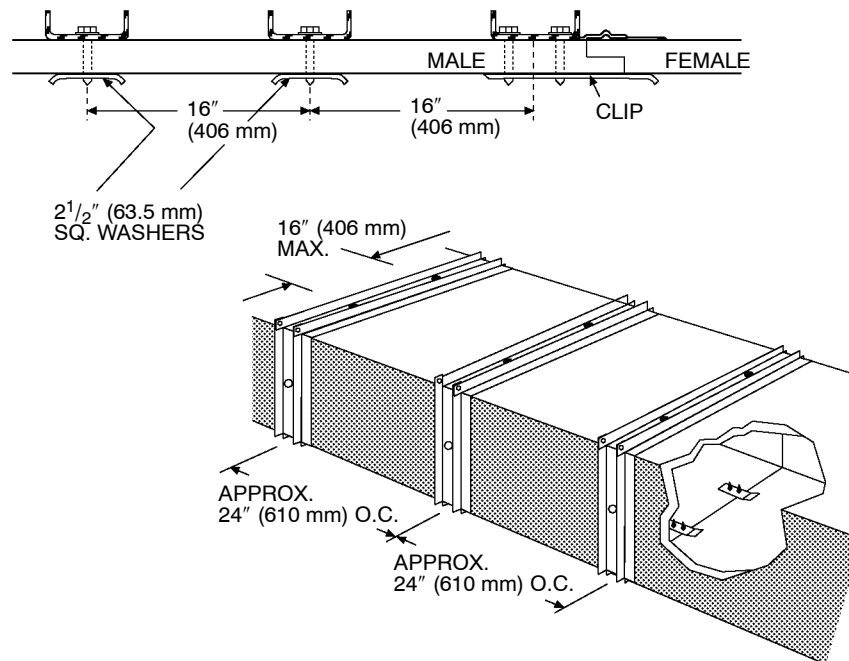


FIGURE A6-3-15—CHANNEL REINFORCEMENT ON 24-INCH (610 mm) CENTERS, 48-INCH (1219 mm) DUCT SECTION

**6.304.4.3 Additional fasteners.** When additional channels are required [as with 24-inch and 16-inch (610 mm and 406 mm) spacing], they are attached to the duct with No. 10 plated sheet metal screws and 2 1/2-inch (64 mm) square washers (see Detail A of Figure A6-3-12).

The spacing of the fasteners through each reinforcement channel is the same as for joint clips (see Table A6-3-C). A typical layout for negative-pressure ductwork is shown in Figure A6-3-15 and Detail C.

#### 6.304.5 Fitting Reinforcement—Positive-pressure Systems.

**6.304.5.1 General.** Fittings are reinforced with tie rods or channels based on the duct dimensions, using the criteria found in Tables A6-3-A and A6-3-B.

Some fittings, branches, tees or offsets may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

**6.304.5.2 Partial wraparound reinforcement.** Where reinforcement is required but cannot be fastened to opposite sides of a duct section or fitting, it is necessary to install formed sheet metal channels that partially wrap around a fibrous glass duct system fitting at the required location. (See Table A6-3-B for appropriate gage and profile.) In such cases, No. 10 by 1 1/4-inch (31.8 mm) plated sheet metal screws and 2 1/2-inch (64 mm) square washers, 0.020 inch (0.51 mm) (minimum) thick, are used to attach the ends of the channels to the duct board. (See Detail D and Table A6-3-D.)

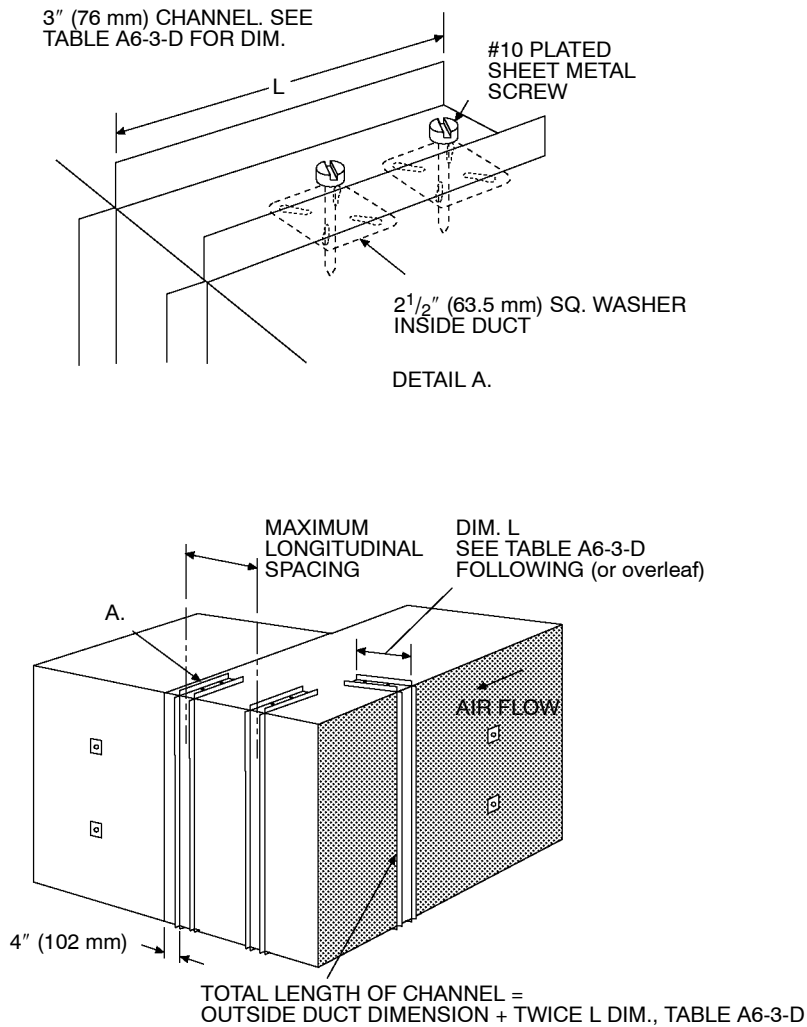


FIGURE A6-3-16—PARTIAL WRAP-AROUND REINFORCEMENT

TABLE A6-3-D—PARTIAL WRAP-AROUND REINFORCEMENT

PARTIAL WRAP-AROUND REINFORCEMENT SCHEDULE								
Positive Static Pressure	Type 475 Board				Type 800 Board			
	Maximum inside Duct Dimension (inches)	Longitudinal Spacing	Dimension L	No. of Screws, Each End	Maximum inside Duct Dimension (inches)	Longitudinal Spacing	Dimension L	No. of Screws, Each End
× 249 for Pa	× 25.4 for mm				× 25.4 for mm			
0" to 1½" w.g.	0-36	Not required			0-36	Not required		
	37-96	24"	4"	1	37-60	48"	4"	1
					61-96	24"		
Over 1½" to 1" w.g.	0-24	Not required			0-24	Not required		
	25-48	24"	4"	1	25-30	48"	4"	1
	49-64		7"	2	31-48	24"		
	65-80		10"	3	49-64		10"	3
	81-96		13"	4	65-80	13"	4	
					81-96			
Over 1" to 2" w.g.	0-15	Not required			0-18	Not required		
	16-24	24"	4"	1	19-24	24"	4"	1
	25-32				25-32		7"	2
	33-48	16"	7"	2	33-48		10"	3
	49-64		10"	3	49-60		13"	4
	65-80		13"	4	61-64	16"	10"	3
	81-96		16"	5	65-80		14"	
					81-96	16"	16"	5

**6.304.5.3 Fitting reinforcement—90-degree elbows.** If neither dimension A nor B (see Figure A6-3-17) is greater than the maximum unreinforced duct dimension (see Table A6-3-A), but diagonal X-Y is greater than the maximum unreinforced duct dimension in accordance with Table A6-3-A, install tie-rod reinforcement at midspan of diagonal at point No. 1 in Figure A6-3-17.

If either A or B is greater than the maximum unreinforced duct dimension:

Reinforce in accordance with Table A6-3-A.

Reinforce 4 inches (102 mm) upstream from female shiplap joints.

Reinforce at point No. 1 (Figure A6-3-17) where center lines intersect.

**NOTE:** Turning vanes in Figure A6-3-17 are omitted for clarity. Turning vanes do not replace reinforcement.

If duct dimension *H* (see Figure A6-3-18) is less than the maximum unreinforced duct dimension from Table A6-3-A, but more than 24 inches (610 mm), install sheet metal angle in accordance with Detail E. (Angle may also be installed on inside of throat.)

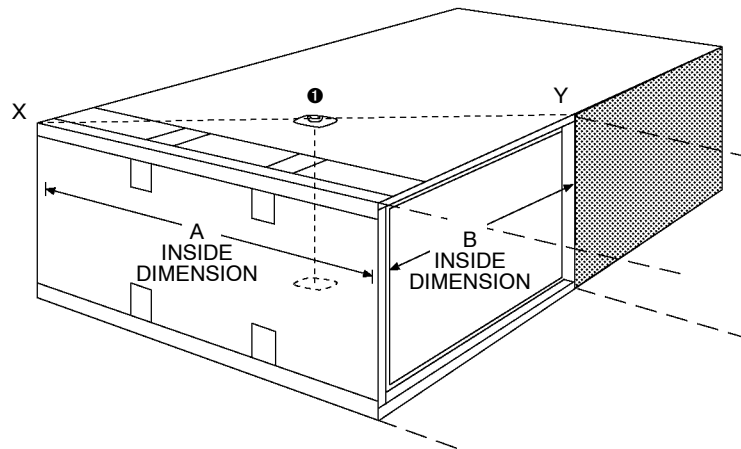
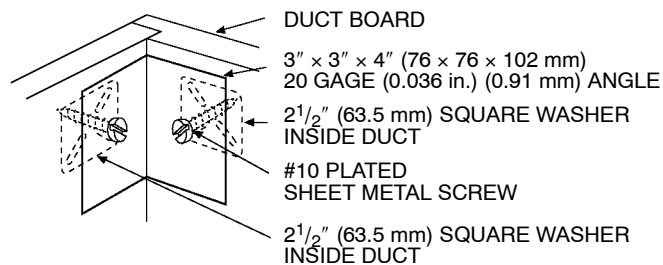
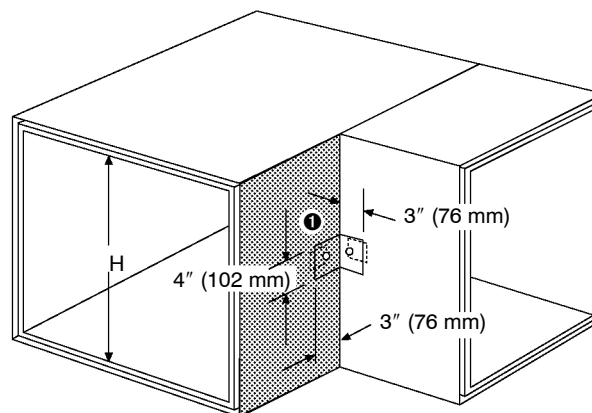


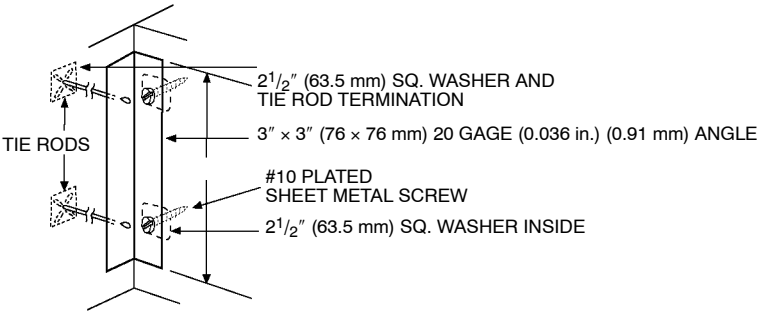
FIGURE A6-3-17—TIE-ROD REINFORCEMENT AT DIAGONAL X-Y—MIDSPAN



DETAIL E—THROAT REINFORCEMENT



SHEET METAL ANGLE REINFORCEMENT AT THROAT OF 90-DEGREE ELBOW



DETAIL F—THROAT REINFORCEMENT

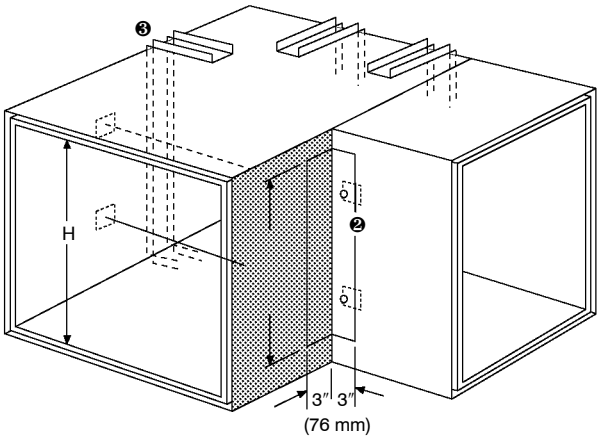


FIGURE A6-3-18—SHEET METAL ANGLE AT THROAT LARGE 90-DEGREE ELBOWS

When duct dimension *H* normally requires reinforcing, install sheet metal angle as shown at No. 2, Figure A6-3-18 and Detail F. Install tie rods through angle on upstream side, 16 inches (406 mm) on center, in accordance with Table A6-3-A, with angle of length *L* from table below.

No. Tie Rods	1	2	3	4	5
	× 25.4 for mm				
Angle Length <i>L</i> , in.	4	20	36	52	68

Install 3-inch (76 mm) channel reinforcement on heel panels as shown in Figure A6-3-18, spaced in accordance with Table A6-3-D and fastened in accordance with Figure A6-3-16.

**NOTES:** 1. Attachment of angles is best done after closure is completed. This requires sections to be short

enough to allow the installer to reach inside to install the 2½-inch (64 mm) square washers.

2. For reinforcement of mitered elbows, refer to reinforcement standards for offsets.

**6.304.5.4 Branch connections (tees).** Many branches may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

Angled branches and positive takeoffs may be reinforced using the same methods as for tees. The amount and type of reinforcement depends on the dimensions of the takeoff and the system pressure (see Table A6-3-A).

If *H* is not greater than 16 inches (406 mm) and *W* (see Figure A6-3-19) is greater than 12 inches (305 mm), install reinforcement in accordance with Detail E on the top of the branch where it intersects the trunk duct.

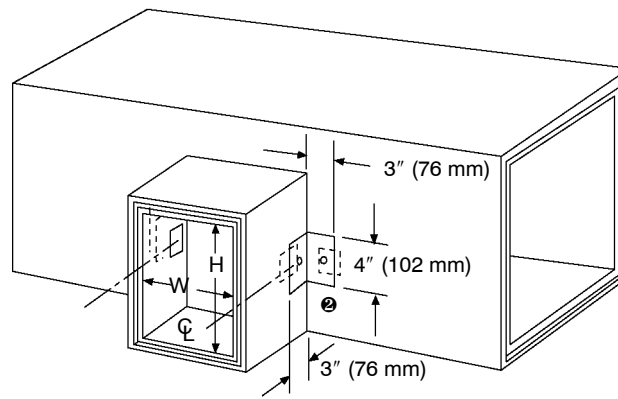


FIGURE A6-3-19—SHEET METAL ANGLE REINFORCEMENT; SIDES OF BRANCH

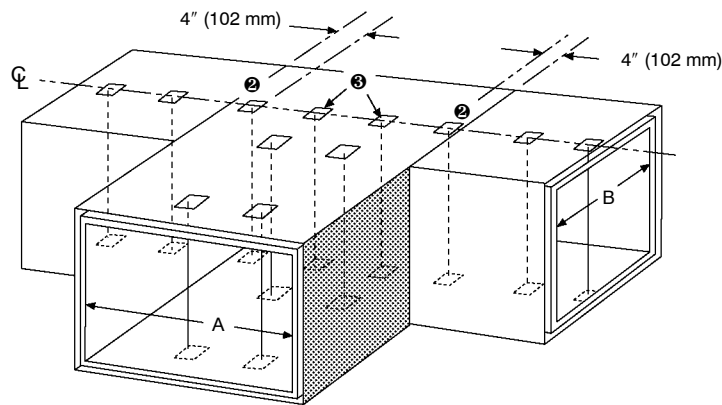


FIGURE A6-3-20—TEE REINFORCEMENT NORMAL TIE-ROD LOCATIONS

If  $H$  is greater than 16 inches (406 mm) and  $W$  is less than the maximum unreinforced duct dimension, reinforce side of branch as shown at No. 2, Figure A6-3-19.

**NOTE:** The maximum unreinforced dimension is 36 inches (914 mm) at  $\frac{1}{2}$  inch w.g. (124 Pa), 24 inches (610 mm) at 1 inch w.g. (249 Pa), and 16 inches (406 mm) at 2 inches w.g. (498 Pa).

If  $H$  (Figure A6-3-19) is greater than 16 inches (406 mm) and  $W$  is greater than the maximum unreinforced duct dimension (see Table A6-3-A), install long angle clips in accordance with Detail C of Figure A6-3-15 with tie-rod reinforcement through the branch and trunk ducts (similar to Figure A6-3-18) as required by Table A6-3-A. A combination of tie rods and partial wraparound reinforcement (see Figure A6-3-16) may be used.

If  $A$  (see Figure A6-3-20) is less than the maximum unreinforced duct dimension but diagonals  $X-Y$  or  $Y-Z$  exceed the maximum allowable unreinforced duct dimension, install tie rods as shown at No. 2, 4 inches (101 mm) from female shiplaps.

If  $A$  is greater than the maximum unreinforced duct dimension and  $B$  is greater than one half the maximum unreinforced duct di-

mension, install tie rods 4 inches (101 mm) from female shiplap joints as shown at No. 2 and also along branch center lines and, additionally, spaced per Table A6-3-D in the trunk duct.

Where a splitter damper interferes with tie-rod reinforcement, wraparound channels must be used in their place.

**NOTE:** Turning vanes do not replace reinforcement.

**6.304.5.5 Offsets.** Offsets require different types of reinforcement for the cheek panels (sides, as shown in Figure A6-3-21) and the heel and throat panels (top and bottom, per Figure A6-3-22).

If  $B$  is greater than the maximum unreinforced duct dimension and cheek panels have shiplap joints, reinforce in accordance with No. 1, 4 inches (101 mm) from female shiplap (see Figure A6-3-21) with spacing in accordance with Table A6-3-A.

If the fitting uses butt joints, install the required spacing of tie rods 3 inches (76 mm) on each side of the butt joint.

Where Table A6-3-A requires more than one row of reinforcement, the rows shall be parallel to the edges of the duct, and the spacing between sets of tie rods shall be in accordance with Table A6-3-A.

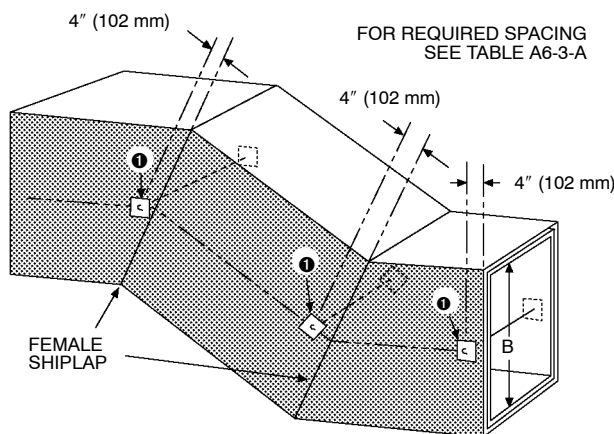


FIGURE A6-3-21—OFFSET REINFORCEMENT CHEEK PANELS WITH SHIPLAP JOINTS

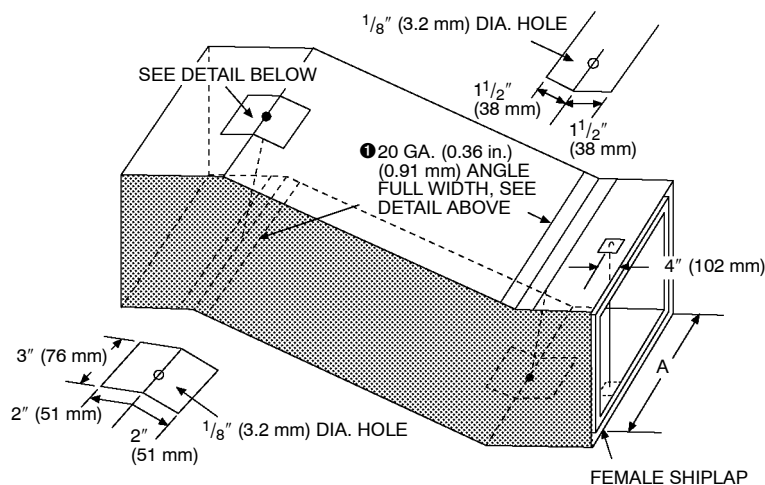


FIGURE A6-3-22—OFFSET REINFORCEMENT WITH SHEET METAL PLATES AND TIE RODS

The reinforcement for heel and toe joints is in accordance with Figure A6-3-22. Additional tie rods may be installed by using a longer plate at the heel, and also in the duct panel spaced in accordance with Table A6-3-A. The penetrations at the toe plate are grouped as close to the break in the metal as possible.

When dimension *A* requires more than one tie rod (see Table A6-3-A), sets of tie rods with metal angles shall be installed in rows parallel to the side of the duct.

Transitions are reinforced in the same manner with a tie rod ex-

tending from the flat side of the duct, through a plate or plates positioned on the heel joint of the fitting.

**6.304.5.6 Access doors—Positive pressure.** If the access door width is not greater than the maximum longitudinal reinforcement spacing from Table A6-3-A, but interferes with reinforcement locations required by the table, install tie rods 4 inches (101 mm) from both sides of door opening in accordance with No. 1, Figure A6-3-23. Maximum reinforcement spacing must be in accordance with Table A6-3-A.

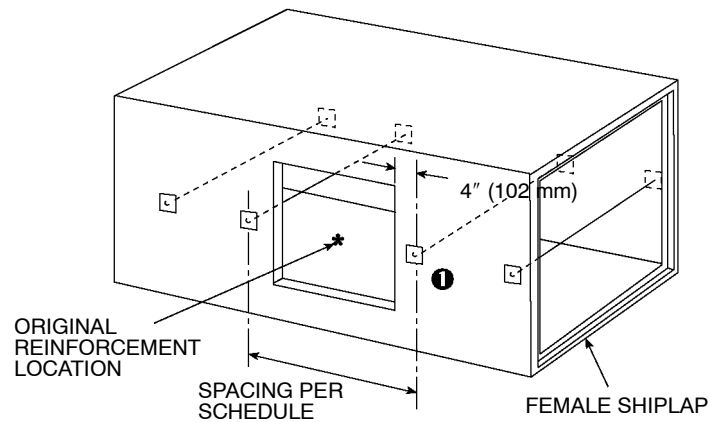


FIGURE A6-3-23—ACCESS DOOR LOCATION INTERFERING WITH REINFORCEMENT

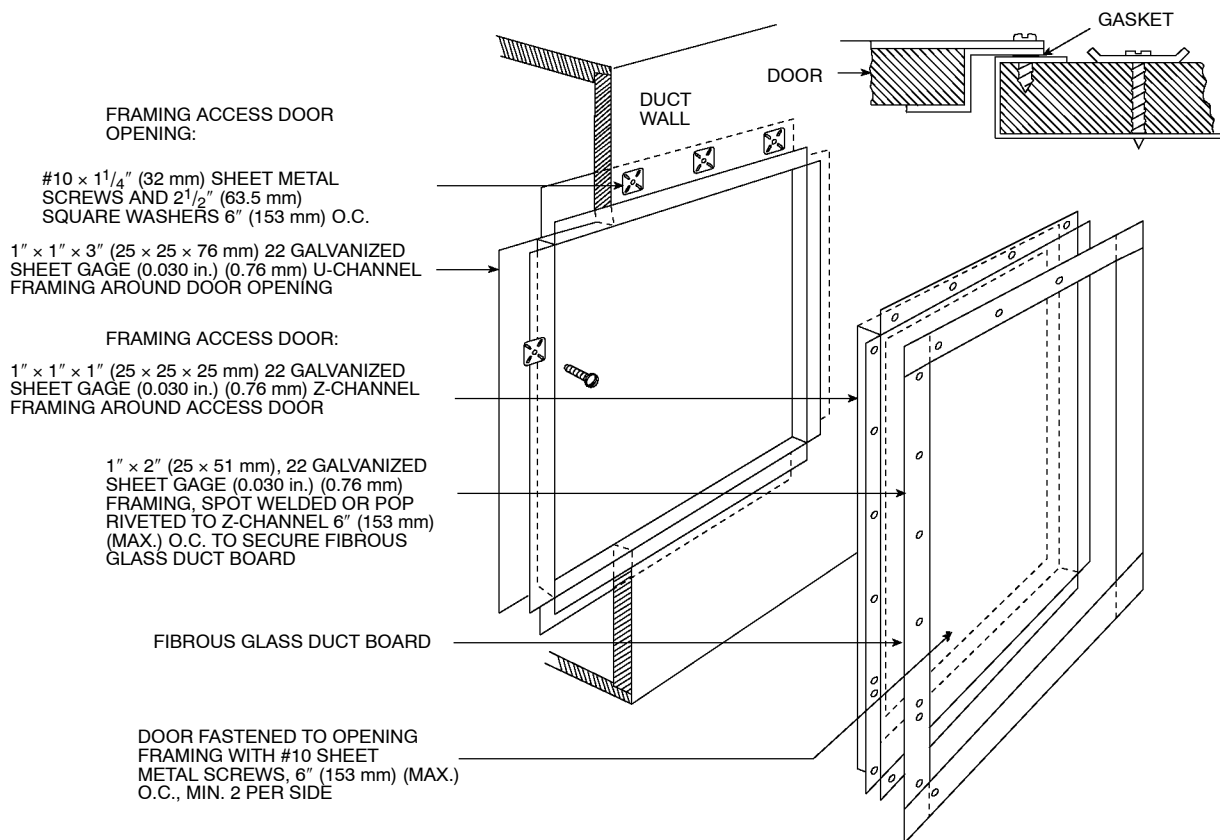


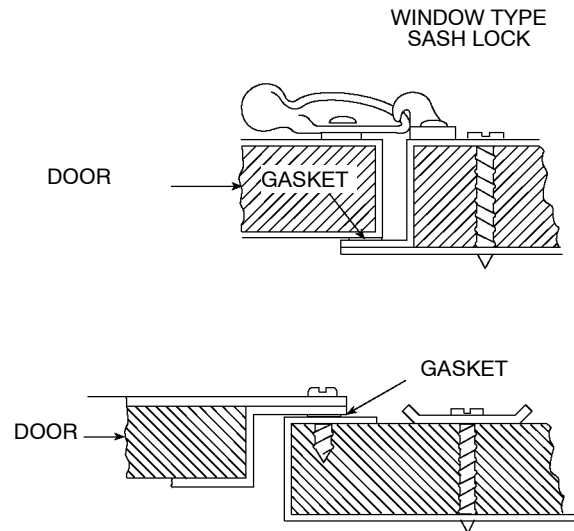
FIGURE A6-3-24—DUCT OPENING FRAME

If access door height is greater than 16 inches (406 mm) and its width is greater than the maximum longitudinal reinforcement spacing shown in Table A6-3-A, install the frame for the access door inside the duct, securing it to the duct wall with screws and washers (see Figure A6-3-24).

Install tie rods near the vertical sides of the door (Figure A6-3-23) frame and also near the top and bottom sides of the frame, spaced as specified in Table A6-3-A with a minimum of one tie rod on each side of the frame.

**NOTE:** Use channel reinforcement in place of tie rods between access door and fire damper where tie rods would interfere with damper access or operation.

The duct door is fabricated from 1 inch (25 mm) duct board installed with 1-inch by 1-inch by 1-inch (25 mm by 25 mm by 25 mm), 22 gage (0.76 mm) Z-channel framing around access door. Doors are gasketed and secured in place with sheet metal screws, or they may be hinged with sash lock fasteners as shown in Detail G on the following page.



DETAIL G—WINDOW TYPE SASH LOCK

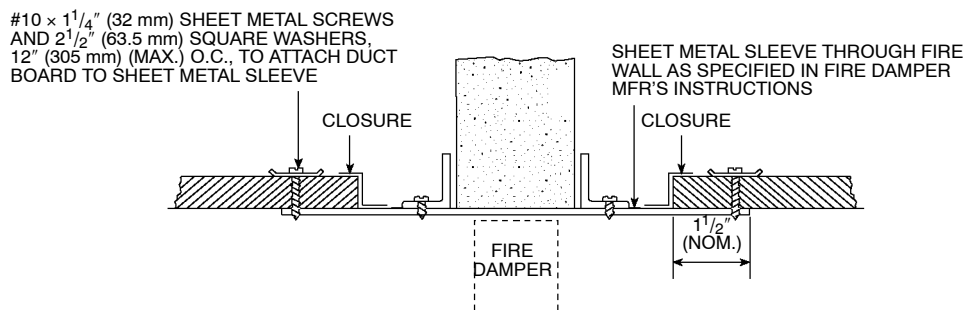


FIGURE A6-3-25—ATTACHMENT TO FIRE DAMPER SLEEVES

## SECTION 6.305 — FIRE DAMPERS

When fire dampers are required at penetrations of fire-rated walls, fibrous glass ducts must terminate at either side of such walls. Fire dampers shall be installed in accordance with the damper manufacturer's instructions and must be installed in a steel sleeve. The opening in the wall shall be large enough to allow for thermal expansion of the sleeve and to permit installation of <sup>5</sup>/<sub>8</sub>-inch (16 mm) gypsum board between the sleeve and framing.

The sleeve must extend not less than 3 inches (76 mm) beyond the face of the wall so that the duct can be slipped onto the sleeve. The duct is secured to the sleeve with screws and washers, as shown in Figure A6-3-25.

Sealing of fibrous glass duct board to the sheet metal sleeve must be made with glass fabric and mastic, except where operating pressure is less than 1-inch w.g. (249 Pa) and the sheet metal surfaces are carefully cleaned, in which case pressure-sensitive aluminum foil tape may be used. See Section 6.303 for methods.

## SECTION 6.306 — HANGERS AND SUPPORTS

**6.306.1 General.** Fibrous glass ducts are light in weight, so that they can be supported with a minimum of hangers if care is taken as to placement of the supports.

The charts and examples illustrated in this section show that the hanger treatment and spacing required is dependent on duct dimensions. Trapeze-style channels suspended by 12 gage (2.1 mm) (minimum) hanger wire (see Figure A6-3-26) are the preferred method of support. Channel gage and profile vary with duct size, but in no case should the supporting channel be less than 2 inches (51 mm) wide. Channels may also be suspended by means of metal rods of 1-inch-wide (25 mm) (minimum) galvanized steel straps.

When channel reinforcement members occur within maximum hanger spacing as shown in Table A6-3-E, sheet metal straps may be bolted to the channel reinforcement as shown in Figure A6-3-27. Support may also be made with 12 gage (2.1 mm) (minimum) wire.

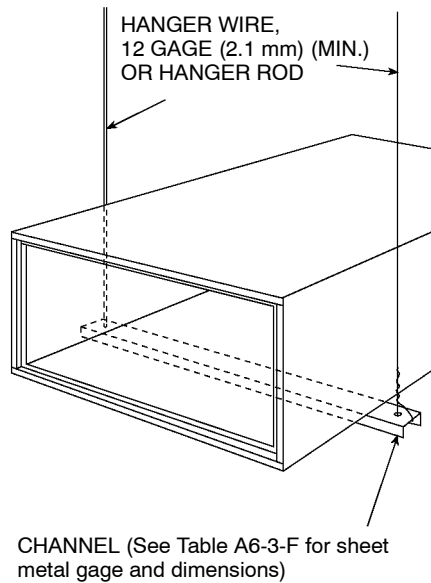


FIGURE A6-3-26—TYPICAL HANGER

TABLE A6-3-E—HANGER SPACING

DUCT SIZE (× 25.4 for mm)	MAXIMUM HANGER SPACING (feet) (× 304.8 for mm)
48" wide or greater	4
Less than 48" wide and less than 12" deep	6
Width between 24" and 48" and greater than 24" deep	6
Less than 48" wide and depth between 12" and 24"	8
Width 24" or less and depth greater than 12"	8

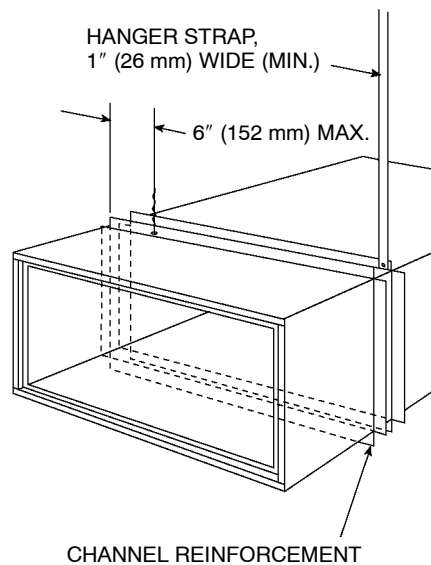


FIGURE A6-3-27—HANGING FROM CHANNEL REINFORCEMENT

**6.306.2 Hanger Design.** Occasionally, hanger channels must be extended considerably beyond the duct sides so that the supports will clear other obstructions. The total extension ( $E + E'$ ) of the supports beyond the duct sides (see Figure A6-3-28) governs the

minimum dimensions (see Table A6-3-F) of the channel.

**6.306.3 Spacing.** Hanger spacing per Table A6-3-E or Figure A6-3-29 is based on 3-inch-wide (76 mm) (minimum) channels.

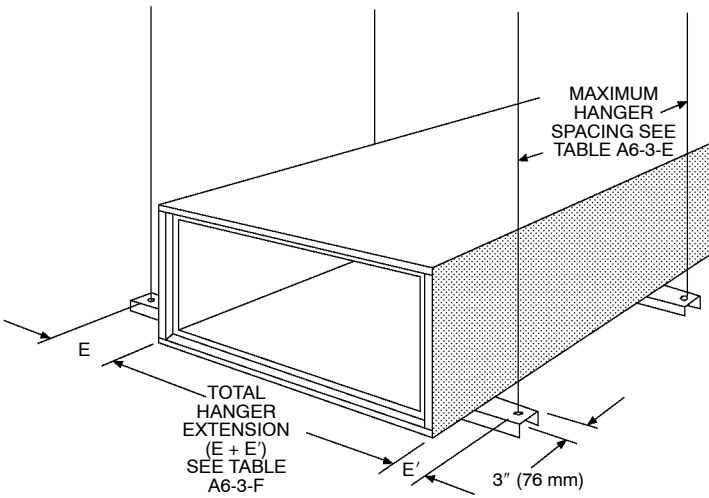
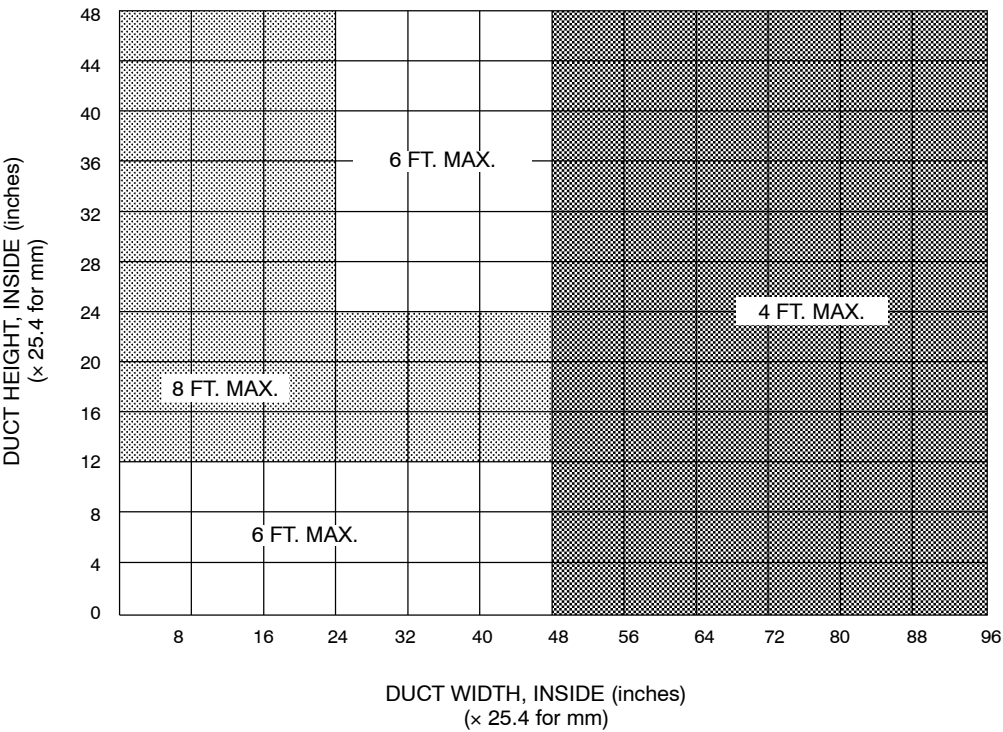


FIGURE A6-3-28—HANGER SPACING AND EXTENSION USING 3-INCH-WIDE (76 mm) CHANNELS

TABLE A6-3-F—CHANNEL SELECTION

IF TOTAL EXTENSION IS NOT GREATER THAN: (inches)	MINIMUM CHANNEL GAGE	MINIMUM CHANNEL PROFILE (inches)
		× 25.4 for mm
6	24	3 × 1.5
18	22	3 × 2
30	18	3 × 2



1 ft. = 305 mm

FIGURE A6-3-29—MINIMUM HANGER SPACING, STRAIGHT DUCT, 3-INCH-WIDE (76 mm) CHANNEL

For ducts not over 48 inches wide by 24 inches high (1219 mm by 610 mm), 2-inch-wide by 1½-inch channels (51 mm by 38 mm), spaced not more than 4 feet (1219 mm) apart may be installed. The total extension of the hanger supports shall not exceed 6 inches (152 mm).

Hanger design and spacing for fibrous glass ducts is based on extensive testing with loads exceeding twice the duct weight located between supports to ensure the integrity of the duct system. Recommended hanger spacing is shown in Figure A6-3-29. Caution should be taken with other types of hanger systems to ensure that excessive stress is not placed on the hanger or the fibrous glass duct system.

**6.306.4 Fittings.** Proper support of duct fittings may require that additional hangers be installed.

For an elbow, hangers should be on each leg, within 12 inches (305 mm) of the throat. If the width of the duct is greater than 18 inches (457 mm), an additional hanger must be installed (see Figure A6-3-30) so that dimension *D* is approximately two thirds of the diagonal distance from throat to heel.

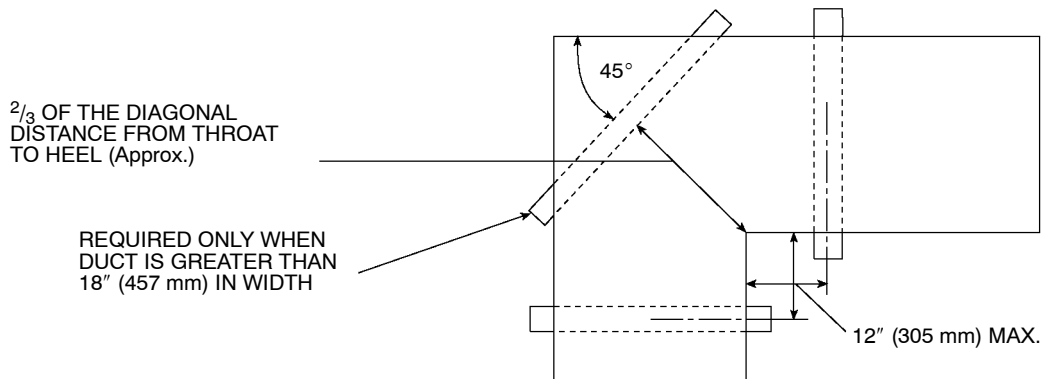


FIGURE A6-3-30—ELBOW SUPPORT

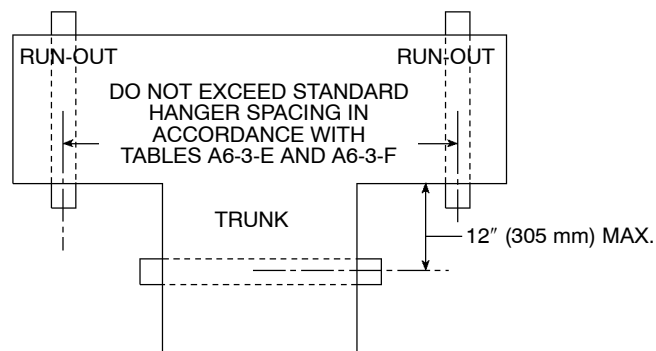


FIGURE A6-3-31—TEE SUPPORT

Tees require support on the trunk as shown in Figure A6-3-31. If a tee run-out hanger falls where the trunk duct is located, add hangers on either side of trunk. Do not exceed maximum hanger spacing.

Branch ducts are treated in a similar manner with hanger spacing on the trunk duct in accordance with Figure A6-3-29.

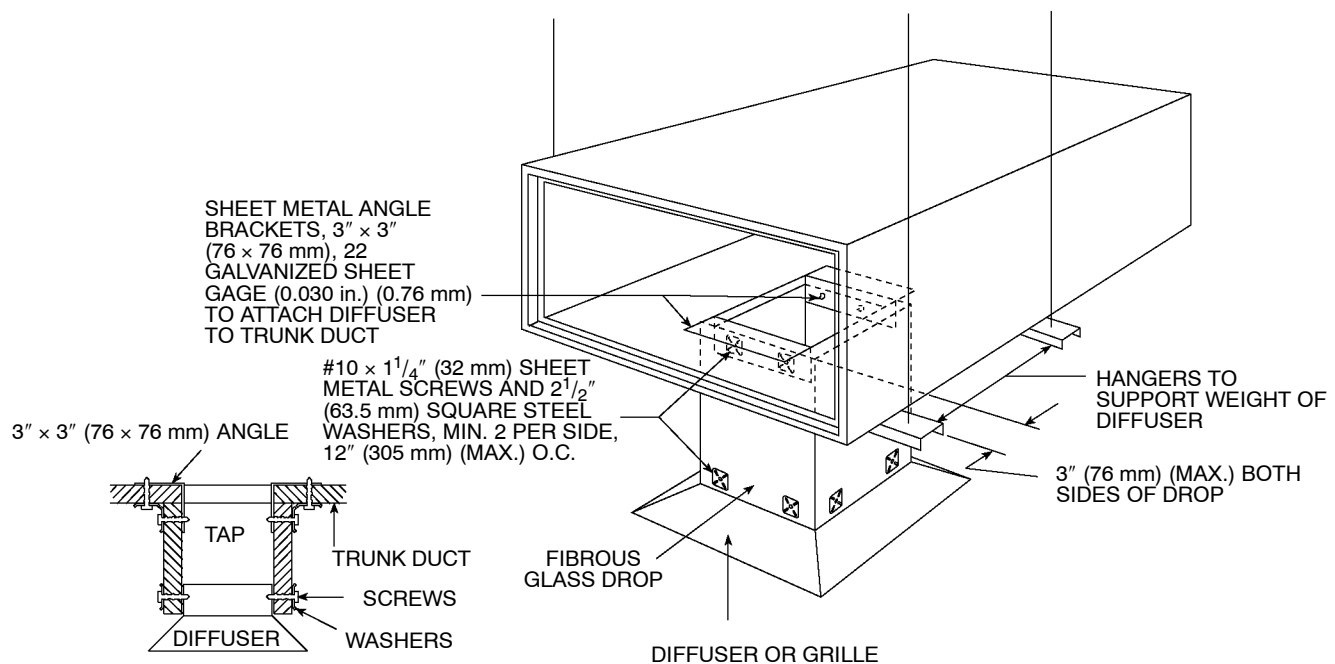
For diffuser drops, hangers are installed within 3 inches (76 mm) of each side of the drop. The connection of the drop to the duct is reinforced in accordance with Figure A6-3-32.

If the drop assembly, including the diffuser, weighs more than 25 pounds (11.3 kg), the diffuser must be separately supported.

**6.306.5 Hanging Rigid Round Duct.** Preformed round fibrous glass duct should be hung so the hanger will not damage the duct facing.

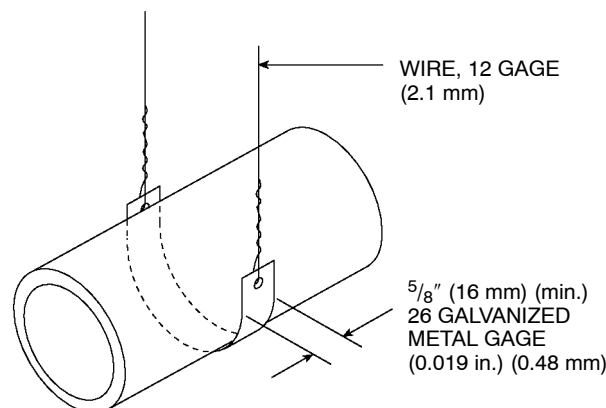
Straps or saddles in contact with the duct must not be less than 5/8 inch (16 mm) wide. Avoid sharp edges and burrs.

Space hangers at a maximum of 6 feet (1829 mm) on center. Where practical, hangers should be located at circumferential joints. Provide hanger support at all fittings.



(See Appendix D for sheet gage equivalents.)

**FIGURE A6-3-32—DIFFUSER CONNECTION**



(See Appendix D for sheet gage equivalents.)

**FIGURE A6-3-33—HANGING ROUND DUCT WITH SADDLE AND 12 GAGE WIRES**

## Part B—Flexible Ducts

### SECTION 6.307 — SUITABLE INSTALLATIONS

#### 6.307.1 General.

**6.307.1.1** The routing and length of flexible duct, the number of bends, the number of degrees of each bend and the amount of sag allowed between support joints will have serious effects on system performance due to the increased resistance each introduces. Use the minimum length of flexible duct to make connections. It is not recommended that excess lengths of ducts be installed to allow for possible future relocations of air terminal devices.

**6.307.1.2** Avoid installations where exposure to direct or indirect

sunlight can occur, e.g., turbine vents, skylights, canopy windows, etc. Prolonged exposure to sunlight will cause degradation of the vapor barrier.

**6.307.1.3** Terminal devices shall be supported independently of the flexible duct.

**6.307.1.4** Repair torn or damaged vapor barrier jacket with approved duct tape. If internal core is penetrated, replace flexible duct or treat as a connection.

#### 6.307.2 Installation.

**6.307.2.1** Install duct fully extended, do not install in the compressed state or use excess lengths. This will noticeably increase friction losses.

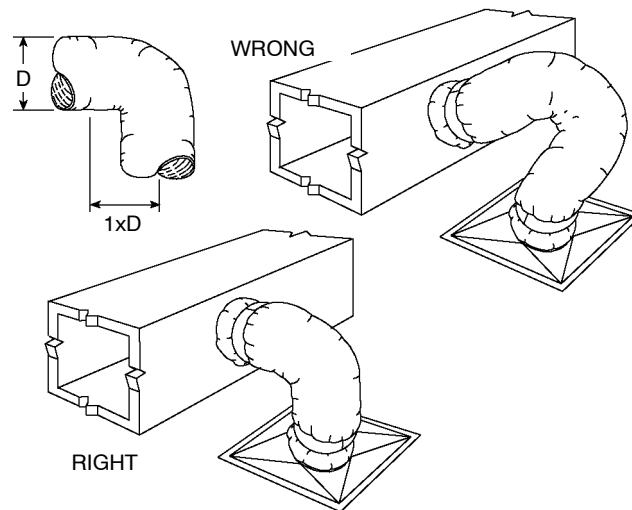


FIGURE A6-3-34—EXTEND DUCT FULLY

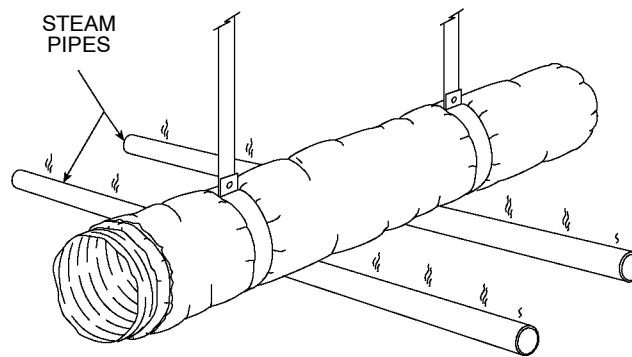


FIGURE A6-3-35—WRONG METHOD OF SUPPORT

**6.307.2.2** Avoid bending ducts across sharp corners, or incidental contact with metal fixtures, pipes or conduits. Radius at center line shall not be less than one duct diameter.

**6.307.2.3** Do not install near hot equipment (e.g., furnaces, boilers, steam pipes, etc.) that is above the recommended flexible duct use temperature.

## SECTION 6.308 — CONNECTING, JOINING AND SPLICING FLEXIBLE DUCT

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions. Unless specified by the manufacturer, adhesives are not recommended for use with nonmetallic flexible duct as they will chemically react with the duct materials, causing deterioration and degradation. Sheet metal collars to which the flexible ducts are attached shall be a minimum of 2 inches (51 mm) in length. Sheet metal sleeves used for joining two sections of flexible duct shall be a minimum of 4 inches (102 mm) in length.

### Installation Instructions Nonmetallic Air Ducts with Plain Ends

#### 6.308.1 Connections.

**6.308.1.1** After desired length is determined, cut completely around and through duct with knife. Cut wire with snips or side cutters.

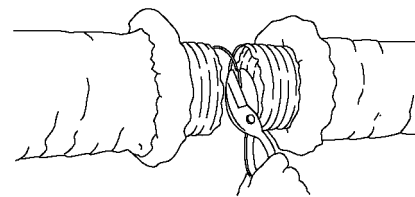


FIGURE A6-3-36A—END CONNECTORS

**6.308.1.2** Pull back jacket and insulation from core. Slide at least 1 inch (25 mm) of core over collar, pipe or fitting. Tape with at least two wraps of approved duct tape. Secure with approved clamp.

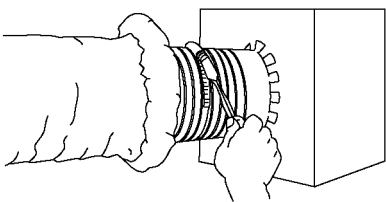


FIGURE A6-3-36B—PULL JACKET AND INSULATION

**6.308.1.3** Pull jacket and insulation back over core. Tape jacket with two wraps of approved tape. An approved clamp may be used in place of or in conjunction with duct tape.

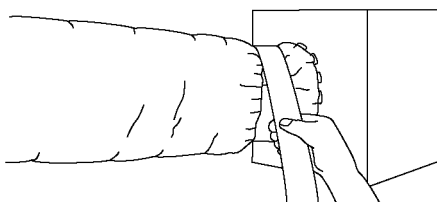


FIGURE A6-3-36C—SPLICES

### 6.308.2 Splices.

**6.308.2.1** Peel back jacket and insulation from core. Butt two cores together on a minimum 4-inch-wide (102 mm) collar.

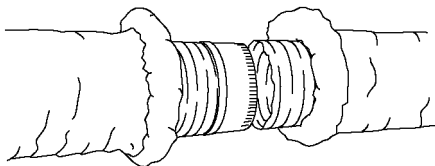


FIGURE A6-3-37A—SPLICING

**6.308.2.2** Tape together with at least two wraps of approved duct tape. Secure with two approved clamps.

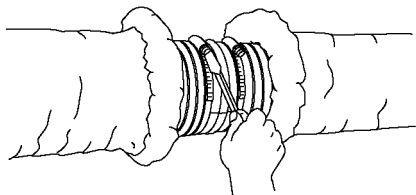


FIGURE A6-3-37B—DUCT CLAMPS

**6.308.2.3** Pull jacket and insulation back over cores. Tape jackets together with two wraps of approved duct tape.

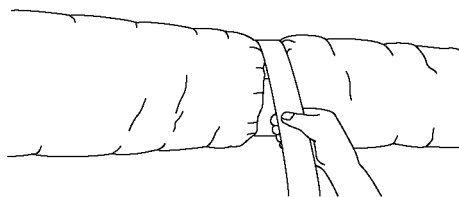


FIGURE A6-3-37C—RETAPE

- NOTES:**
1. For uninsulated duct/connector, disregard reference to insulation and jacket.
  2. See manufacturer's installation instructions for approved tapes and clamps.
  3. Use beaded fittings for pressures exceeding 4 inches w.g. (955 Pa) and for diameters 12 inches (305 mm) and larger.

## SECTION 6.309 — SUPPORTING FLEXIBLE DUCT

**6.309.1** Flexible duct shall be supported at manufacturer's recommended intervals, but at no greater distance than 4 feet. Maximum permissible sag is  $\frac{1}{2}$  inch per foot (42 mm/m) of spacing between supports.

A connection to rigid ducting or equipment shall be considered a support joint.

Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter distance from the center line of the bend.

**6.309.2** Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than  $1\frac{1}{2}$  inches (38 mm) wide.

**6.309.3** Factory-installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturer's recommended procedures are followed.

**6.309.4** Flexible ducts may rest on ceiling joists or truss supports. A maximum spacing between supports shall not exceed the maximum spacing per manufacturer's installation instructions.

**6.309.5** Support the duct between a metal connection and a bend by allowing the duct to extend straight for a few inches before making the bend. This will avoid possible damage of the flexible duct by the edge of the sheet metal collar.

**6.309.6** Vertically installed duct shall be stabilized by support straps at a maximum of 6 feet (1829 mm) on center.

**NOTE:** Factory-made air ducts may not be used for vertical risers in air duct systems serving more than two stories. See Section 603.2.

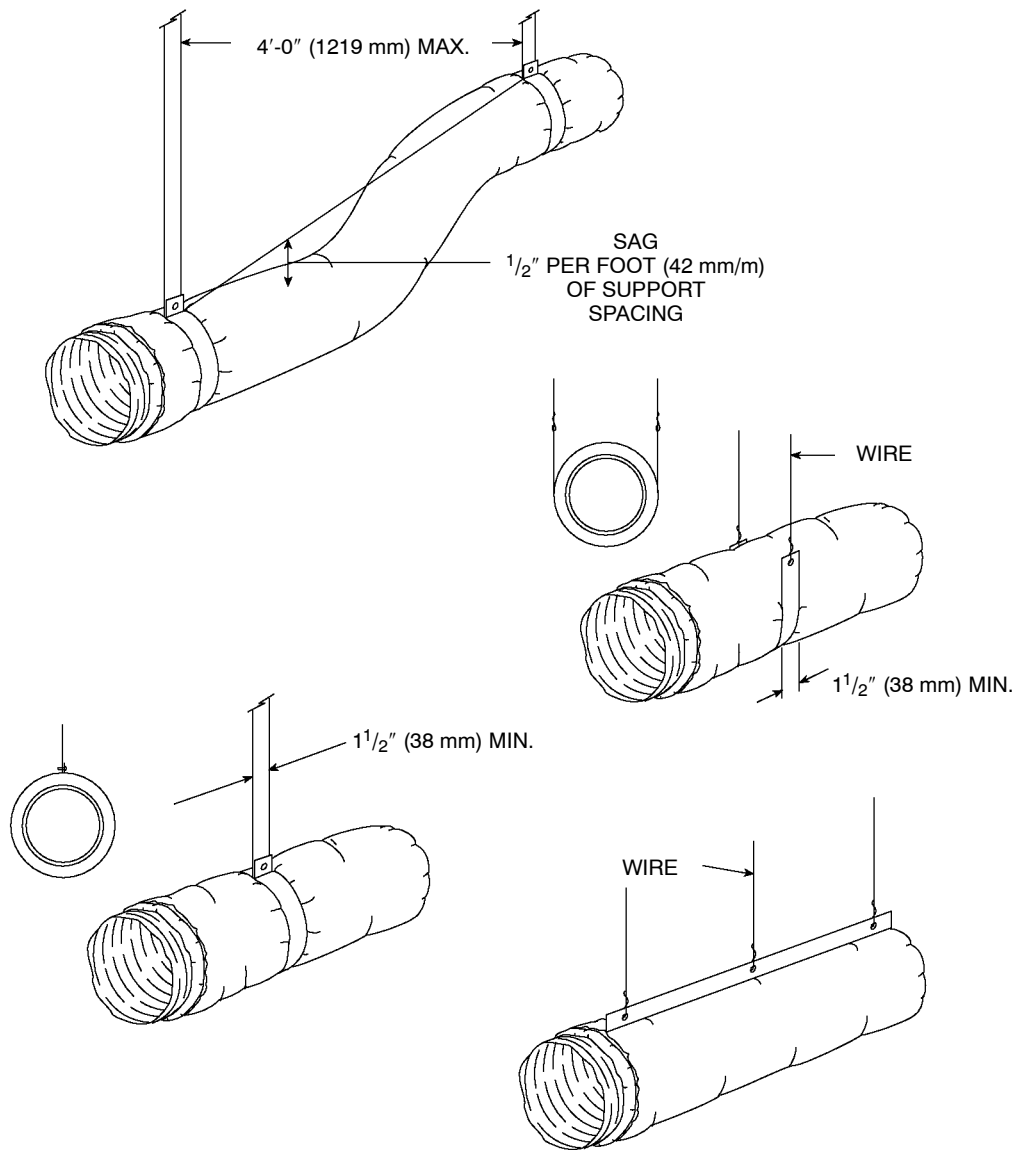


FIGURE A6-3-38—FLEXIBLE DUCT SUPPORTS

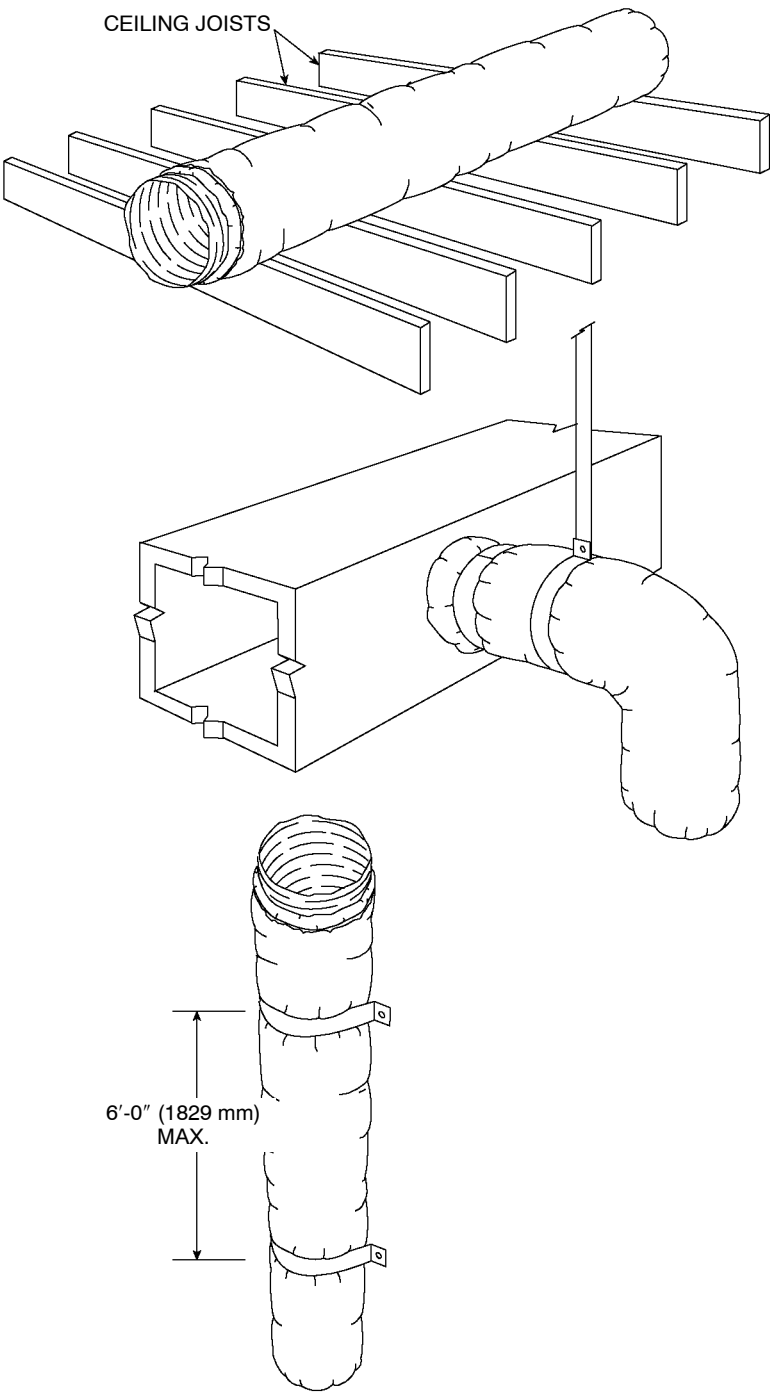


FIGURE A6-3-39—PROPER SUPPORT

SECTION 6.310 — CHECKLIST

The following checklist is provided for the benefit of the inspector, as well as the installer. It is designed so that the correct answer to all questions is yes.

General

- |  |     |     |
|--|-----|-----|
| _____ Have all tears or punctures to facing material been repaired using the proper technique? | Yes | No  |
| _____ Are all sheet metal accessory items galvanized?  | ( ) | ( ) |

Product

- |   |     |     |
|---|-----|-----|
| _____ Is the UL label present? (Although each board is labeled, each section may not be since there is only one label per sheet.) | ( ) | ( ) |
|---|-----|-----|

Fabrication and Installation

- |  |     |     |
|--|-----|-----|
| _____ When metal parts are attached, are 2 1/2-inch (64 mm) (minimum) square steel washers used on 16-inch (406 mm) (maximum) centers? | ( ) | ( ) |
|--|-----|-----|

	Yes	No			
_____ When staples cannot be used, are 8-inch (203 mm) cross tabs of approved closure being used in place of staples? [Tab spacing requirements are 12 inches (305 mm) on center, minimum one per side.]	( )	( )	_____ If heat-sealable tape closure was used, was it applied correctly, as evidenced by dot color change?	( )	( )
_____ Are all system joints tight, free from bulges, with taped joints showing good workmanship?	( )	( )	_____ If glass fabric and mastic are used, is the mesh of the glass fabric completely filled with mastic?	( )	( )
_____ Have offsets been installed so duct sections are not forced to bend around obstructions?	( )	( )	<b>Reinforcement</b>		
<b>Fire Dampers</b>			_____ Is reinforcement system in accordance with Section 6.304?	( )	( )
_____ Is sheet metal sleeve present? Is duct properly attached to sleeve with screws and washers 16 inches (406 mm) on center? (Fibrous glass ducts must not penetrate assemblies required to have a fire damper.)	( )	( )	_____ Is tie-rod spacing correct according to duct span, board type and static pressure?	( )	( )
<b>Access Doors</b>			_____ Are tie-rod washers 2 <sup>1</sup> / <sub>2</sub> inches (64 mm) square?	( )	( )
_____ Is installation in accordance with Section 6.304.5.6?	( )	( )	_____ Do tie-rod washers have turned edges facing away from duct board so they will not cut into it?	( )	( )
<b>Grills, Diffusers, Registers</b>			_____ If tie rods reinforce a butt joint, are rods used on <i>both sides</i> of butt joint?	( )	( )
_____ Is the extra weight of the item being separately supported and not dependent on the duct alone for support? [Exception: Registers not greater than 150 square inches (96.7 × 10 <sup>3</sup> mm <sup>2</sup> ) in area may be attached to the duct with metal channel, without other support.]	( )	( )	_____ Is wire termination one of those documented in Section 6.304.2?	( )	( )
<b>Connection to Units</b>			_____ Are antisag devices used on ducts 48-inch (1219 mm) span or greater, to support top panel of ducts?	( )	( )
_____ Are sheet metal screws and washers used to secure duct system to flange extensions? (Securing the duct to the unit flange without mechanical fasteners is sufficient.)	( )	( )	_____ Are heels of tees, elbows and end caps reinforced (formed sheet metal channel, tie rod, combination)?	( )	( )
<b>Closures</b>			_____ When formed sheet metal channel reinforcement is used, are sheet metal gauges, dimensions and spacing correct?	( )	( )
_____ Are all joints in the system properly sealed?	( )	( )	_____ On return ducts, are sheet metal channel reinforcements attached to ducts with screws and 2 <sup>1</sup> / <sub>2</sub> -inch (64 mm) square washers or 2-inch by 6-inch (51 mm by 152 mm) clips?	( )	( )
_____ Are closure materials of a listed type as evidenced by presence of UL instruction sheet in duct board carton, or imprinted UL 181A on the tape?	( )	( )	<b>Hangers and Supports</b>		
_____ Are there staples or cross tabs, properly spaced, on circumferential joints?	( )	( )	_____ Are hangers installed in accordance with Section 6.306?	( )	( )
_____ Are all pressure-sensitive tape closures rubbed down adequately, with staples or scrim in facing clearly visible through the tape?	( )	( )	_____ Are hanger designs in accordance with Table A6-3-F?	( )	( )
			_____ Are accessories that add weight to the duct system separately supported so as not to stress the system?	( )	( )
			_____ If formed sheet metal reinforcements are used as hangers, are attachments within 6 inches (152 mm) of duct sides?	( )	( )
			_____ Are all fittings supported by hangers?	( )	( )

**CALIFORNIA MECHANICAL CODE**  
**PART 4, TITLE 24, CALIFORNIA CODE OF REGULATIONS**  
**CHAPTER 6**  
**DUCTS**

ADOPTION TABLE 4-10A

CODE SECTION	CEC	CEC
Entire CMC as noted in this table <sup>3</sup>	1998 CMC <sup>1</sup>	2001 CMC <sup>2, 3</sup>
601	X <sup>1</sup>	
603	X <sup>1</sup>	
604	X <sup>1</sup>	
Standard 6-3	X <sup>1</sup>	
601		X <sup>2</sup>
602		X <sup>2</sup>
604		X <sup>2</sup>
605		X <sup>2</sup>
Standard 6-5		X <sup>2</sup>

<sup>1</sup>Prior to the effective date designated by the California Building Standards Commission for the 2001 CMC.

<sup>2</sup>On and after the effective date designated by the California Building Standards Commission for the 2001 CMC.

<sup>3</sup>Adopted by reference for Occupancies A, B, E, F, M, R and S; see Sections 118 (d) 3, 124, 150 (m) and 151 (f) 10.

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